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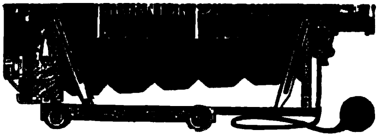


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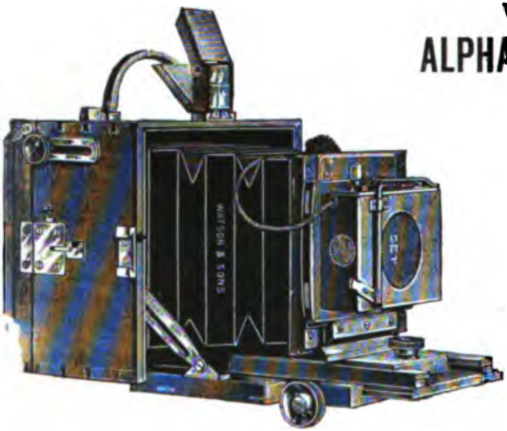

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IN

PHOTOGRAPHY

BY

SIR WILLIAM DE W. ABNEY

K.C.B., D.C.L., F.R.S.

RETIRED CAPTAIN, ROYAL ENGINEERS

TENTH EDITION

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PREFACE TO NINTH EDITION

A FEW remarks are necessary, by way of explanation of some of the changes that have been made in this edition. The gelatine process having so firmly got possession of the photographic public, it has been awarded the place of honour in the description of negative-making processes, relegating the description of the wet process to a more subsidiary position. Certain omissions in some almost obsolete processes have become necessary to keep the pages within reasonable limits, and to make room for various new chapters. The French system of weights and measures which was given in the last edition has been discarded for measures by parts. It has been considered that the grain is the most convenient standard to adopt, and, for simplicity's sake, the weight of 1 ounce of distilled water has been taken as 440 grains instead of 437½ grains, a difference which is not practically felt when dealing with photographic processes. It is much to be desired that dealers should make measures graduated into parts. The present 20 ounce measure would have a capacity of 8800 grains by weight very nearly, and by increasing it slightly it could be graduated into 10,000 parts. The ordinary 4 ounce measure could also be readily slightly increased in size to show 2000 parts. Such graduated measures would at once enable photographers to make up solutions according to foreign formulæ, the gramme being taken as a grain, and the cubic centimetre as one part.

Photography for scientific purposes has passed the experimental and what may be called the qualitative stage of its existence, and in this edition will be found a description of making measurements which convert it into a quantitative agent.

WILLIAM DE W. ABNEY.

PREFACE TO TENTH EDITION

THE publishers' call for a new edition has enabled me to bring the work, it is hoped, quite up to date. This has involved the addition of a large number of pages, which include such subjects as 'Photo-block work,' 'Three-colour printing,' etc. Some additions have also been made to the theoretical side of photography.

The subject of lenses has been treated more fully than before, and substantial extracts have been made from Mr. Child Bayley's history of their evolution, which appeared in the catalogue of the Crystal Palace Photographic Exhibition. To him I owe my thanks, and also especially to Mr. J. McIntosh, who has rendered me most valuable aid in seeing the work through the press.

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CONTENTS

CONTENTS


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11
8
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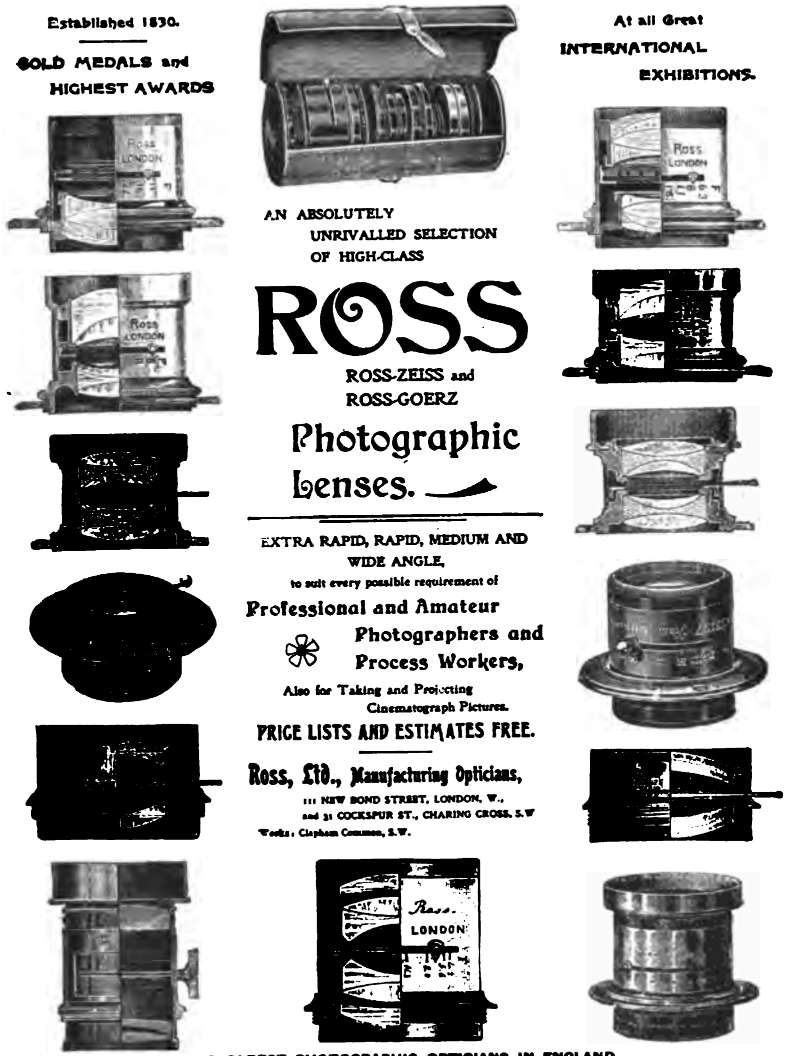
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INSTRUCTION IN PHOTOGRAPHY

CHAPTER I

ACTION OF LIGHT ON SILVER COMPOUNDS

NEARLY every metallic or organic compound undergoes some change in the presence of ordinary light. The change may be visible to the eye, as in the case of the darkening of silver chloride or the bleaching of dyed stuffs ; or it may be invisible, and only to be ascertained by the behaviour of the compound when certain chemical agents are brought in contact with it, as an example of which we may take the case of silver chloride when the exposure is not sufficiently prolonged to have caused a visible darkening. The evidence that a change has been produced in the latter is as strong under these last circumstances as in the former, and, by logical deduction, we arrive at the fact that any difference between a visible change and one which requires the application of a developing agent is only in the *number* of molecules, composing the compound, which are altered.

It will be evident that when an image of, say, some white body in which there are differences in light and shade is formed by a lens on a surface of a compound which can be affected by light, the amount of alteration produced will depend on the different gradations of light acting on it. Similarly, if the light be filtered through a screen in contact with such a surface, and which cuts off different quantities of light, the amount of alteration at the different parts will depend on the quantity of light reaching each of them.

The image of which cognisance can only be taken by the application of a developing solution is often inaccurately called the "latent" image; it is far preferable to call it the "photographic" image. These terms are more particularly applied to the invisible change which takes place in a film containing or formed by a compound of silver; and such compounds as are capable of being impressed by an image are termed "sensitive."

The sensitive salts of silver which are usually employed in photography are, the iodide, the bromide, and the chloride of silver; and they are the compounds which, up to the present, are found to possess the most advantages. There are others which are rarely used, and to which we may refer further on.

Silver iodide (AgI) can be formed in two or more ways—by the action of a soluble iodide on a soluble salt of silver, or by iodine vapour upon metallic silver. The last method is that which was employed in the old Daguerreotype process; the first is that which is used in ordinary photography. In the last case—

Silver and Iodine form Silver Iodide

$$2Ag + 2I = Ag_2I_2$$

In the former, the soluble iodide of a metal, such as cadmium, or of an alkali, such as ammonium, etc., is brought in contact with a solution of silver nitrate. The iodine, having a strong affinity for the silver, forms silver iodide, setting free the nitric anhydride, which, in its turn, combines with the metal originally in combination with the iodine. Chemically, it is expressed thus—

Cadmium Iodide and Silver Nitrate form Silver Iodide and Cadmium Nitrate

$$CdI_2 + 2AgNO_3 = 2AgI + Cd(NO_3)_2$$

If we were to substitute bromine (Br) or chlorine (Cl) for the iodine (I), and a bromide or chloride for the iodide, in the above descriptions, we should describe the formation of silver bromide and silver chloride, the decomposition taking place being similar.

The chemical change that takes place in these three haloid salts, as they are called, by the action of light, whether visible when long, or invisible when short exposure is given to it, we have very good reason to believe to be the formation of a silver sub-haloid; that is, a compound in which one atom of the halogen iodine, chlorine, or bromine is separated from the original molecule, in which two atoms of these are supposed to be combined with two atoms of silver. Amongst other proofs which might be brought forward as to this fact we have, in the case of silver bromide, the fact that when it is given a prolonged exposure to light, bromine is smelt, and chemical tests confirm its presence. Thus—

Silver Bromide gives Silver Sub-bromide and Bromine

$$2AgBr = Ag_2Br + Br$$

We may substitute the chloride or the iodide of silver in the equation for the bromide, and we shall have sub-chloride or sub-iodide formed, with the liberation of chlorine or iodine respectively, though in the case of the iodide the reaction may not, perhaps, be quite so simple.

The fact that there are certain reducing substances which will reduce the salts of silver to the sub-salts, and that such a sub-salt behaves under the action of a developer in the same way as the compound formed by the action of light, is further evidence, if more be required, that, in the latter case, the sub-salt is also formed.

It must not be supposed that this chemical change takes place in the whole of the silver haloid present; far from it. The change, in the case of a short exposure, must take place in an infinitely small and unweighable part of it.

The reduction of the haloid, such as silver bromide, to the sub-haloid takes place with much greater facility if some body be present with the sensitive salt which will at once take up the atoms of the halogen liberated, and, in arriving at the greatest sensitiveness of the silver salt, it is always endeavoured to secure the presence of a body which has the greatest avidity for the halogen, barring only those which would, without the action of light, take it from the silver salt. In the case of the iodide, the halogen absorbent is almost an actual necessity. If, for example, a film of pure iodide of silver be prepared, as in the wet collodion process, and after immersion in the silver bath be washed and treated with iodide of potassium, or iodine in water, and again washed to free it from all excess of soluble iodide or iodine, such a change as that indicated above will take place with extreme difficulty, more especially if dry; but if such a plate be treated with an organic substance, such as beer, or an inorganic substance, such as potassium nitrite, the silver iodide is able to part with its atom of iodine as indicated. In the same way, if silver nitrate be present, it acts as an iodine absorbent. In the case of the organic matter, we have a compound formed with the iodine. One atom of iodine eliminates one of hydrogen, or an hydroxyl (HO) group from the compound, and takes its place, and another combines with the hydrogen or hydroxyl liberated to form hydriodic acid (HI), or this with nascent oxygen. With potassium nitrite, we have—

Iodine, Potassium Nitrite, and Water[*] form Hydriodic Acid and Potassium Nitrate

$$2I + KNO_2 + H_2O = 2HI + KNO_3$$

When silver nitrate is the absorbent, as in the wet collodion process, the reaction is somewhat different. It is usually considered to be as follows:—Multiplying the iodine by 6, we have six atoms of iodine (6I) coming in contact with six atoms of silver nitrate ($6AgNo_3$) and water, and then—

Iodine, Silver Nitrate, and Water produce Silver Iodide, Silver Iodate, and Nitric Acid

[†] $$6I + 6AgNO_3 + 3H_2O = 5AgI + AgIO_3 + 6HNO_3$$

To Dr. Vogel[‡] must be given the credit of laying down the above law regarding the necessity of absorbents of the halogens (I, Br, and Cl), and he has rightly named such bodies *sensitisers*. With silver iodide, under ordinary atmospheric conditions, as we said, such an absorbent is absolutely necessary; but with silver chloride or bromide, the chlorine or bromine will be evolved without it, probably on account of the moisture, which is always ready to combine with them on liberation.

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[*] Plates prepared with potassium nitrite always contain a certain amount of moisture, owing to the hygroscopic nature of the salt.

[†] When bromine and chlorine are liberated from silver bromide and chloride respectively in the presence of silver nitrate, the reaction that takes place may be somewhat different, but not essentially so. In the above equation it is possible that oxygen is liberated, and no iodate formed.

[‡] *Photographic News*, 1865, page 209.

CHAPTER II

THE ACTION OF THE SPECTRUM

We now come to a part of our subject which the beginner may not at first understand and appreciate, though it is in reality most important in its bearings on photographic processes.

When a thin slice of light traverses a prism, it is separated into all its coloured components, and forms what is called a spectrum. The colours pass imperceptibly from one into the other, but, for the sake of perspicuity, they have been divided into seven principal colours. These are red, orange, yellow, green, blue, indigo, and violet. The spectrum is not confined to the rays that are seen, but extends beyond the red. At the violet end also the visible rays do not give the limit of the spectrum. If a card be washed over with a common lubricating oil, such as is used for bicycles, and placed in the spectrum, rays beyond the violet which are usually invisible will flash out, becoming visible. A solution of sulphate of quinine in water acidulated with tartaric or sulphuric acids will also cause the same effect. The spectrum has its greatest brightness or luminosity in the yellow, and fades off towards the red and the violet. Fig. 1 shows approximately what are the ratios of brightness at various parts of the spectrum of direct sunlight at mid-day in summer as determined by the author.* The brightest parts of the spectrum are not those which act most strongly on the salts of silver; indeed, the yellow scarcely affects them; it is the violet and blue, which, as will be seen from the figure, have very small luminosity, that affect them most. Experiment has shown that only the action of those rays which are included between the green and the ultra-violet need be considered as

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* Bakerian Lecture, 1886.

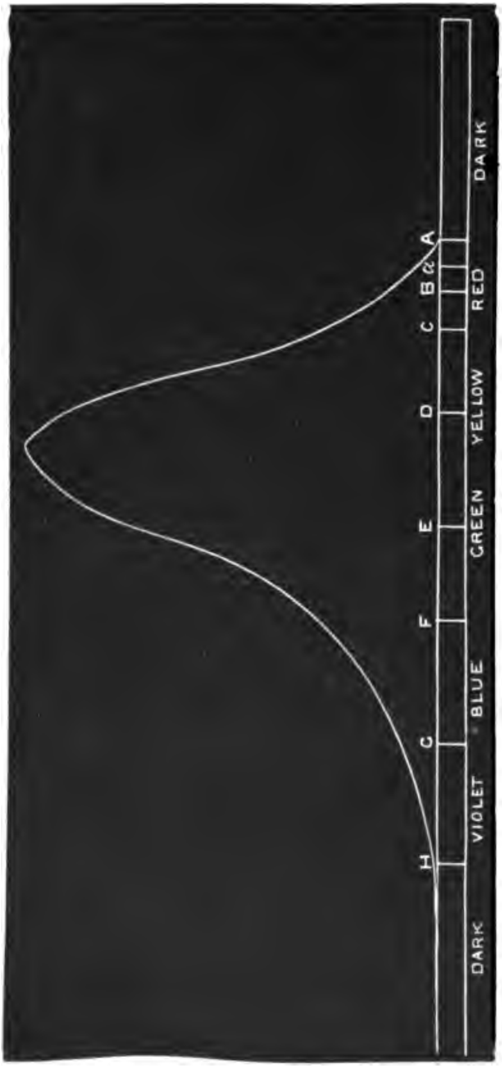

Fig. 1.—The heights of the curve above the horizontal top line give the relative visual intensities of the light.

making any considerable change in the silver compounds which are ordinarily employed by photographers. Those rays of light which do effect a change (visible or invisible) are often termed "actinic" or "chemical rays"; all others, non-actinic. These terms are, however, misleading, except when properly guarded by mental reservations. It entirely depends on the sensitive compound employed as to which rays are "actinic." It will be seen, for instance, that to one modification of silver bromide* all the rays of the visible spectrum, and also part of the invisible infra-red, and ultra-violet, are "actinic," though, for the ordinary silver bromide, the red and infra-red may be classed as "non-actinic."

Most silver compounds—indeed, almost all sensitive compounds—are affected by the ultra-violet rays, and, in some cases, the change produced is more marked at this part of the spectrum than at others. The rays beyond the violet and below the red are usually called ultra-violet and infra-red respectively.

In order to determine as to what rays any particular compound is sensitive, appeal must be made to the spectroscope as applied to photographic purposes. When only approximate knowledge is required, the sensitiveness of a compound may be estimated by the darkness or the opacity of the print or negative obtained by an exposure to the spectrum; but when a really accurate determination is required, resort must be had to some method of measurement. In fig. 2 we have an eye estimation of the amount of blackening or density of deposit on various compounds caused by the different spectral rays. The blackening or density is shown by the height of the curve above the base line.† It will be noticed that the effect of the direct action of light as shown by printing is given in Nos. 1, 3, 5, 7, and 10. In these cases the sensitive salt was formed in ordinary paper by salting the *paper*, as will be described in a subsequent chapter, and then floating it on a solution of silver nitrate, and drying. We may here state that if a collodion film had been used instead of paper, the effects would have been precisely the same as shown in Nos. 2, 4, 6, 9, and 11.

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* *Phil. Trans.*, 1881, Bakerian Lecture; also *Photographic Journal*, 1881, page 95.

† *Proc. Royal Society*, vol. xxxii.; *Photographic Journal*, May 1882.

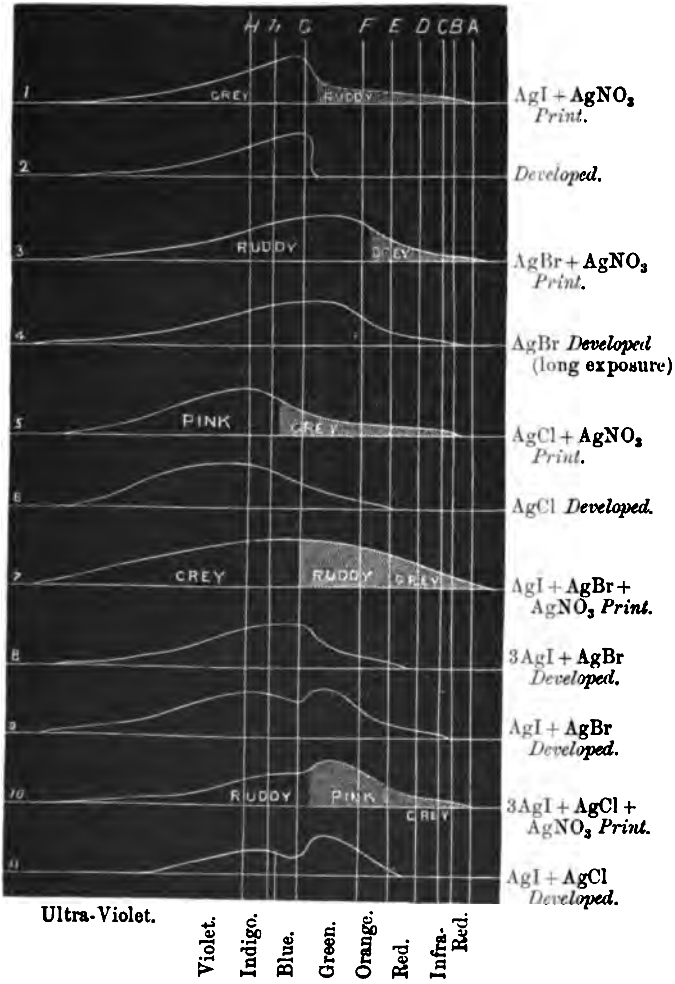
H h G F E D C B A
1
GREY
RUDDY
$AgI + AgNO_3$ *Print.*
2
Developed.
3
RUDDY
GREY
$AgBr + AgNO_3$ *Print.*
4
$AgBr$ *Developed* (long exposure)
5
PINK
GREY
$AgCl + AgNO_3$ *Print.*
6
$AgCl$ *Developed.*
7
GREY
RUDDY
GREY
$AgI + AgBr + AgNO_3$ *Print.*
8
$3AgI + AgBr$ *Developed.*
9
$AgI + AgBr$ *Developed.*
10
RUDDY
PINK
GREY
$3AgI + AgCl + AgNO_3$ *Print.*
11
$AgI + AgCl$ *Developed.*
Ultra-Violet.
Violet.
Indigo.
Blue.
Green.
Orange.
Red.
Infra-Red.

Fig. 2.

No. 2 shows the chemical effect of the spectrum on pure silver iodide, developed by any method.

No. 4 shows the spectrum impressed on silver bromide, developed by any method.

No. 6 shows the spectrum impressed on silver chloride, developed by any method.

No. 8 shows a silver bromo-iodide wet plate.

No. 9 shows a silver bromo-iodide dry plate, developed by any method.

No. 11 shows a silver chloro-iodide dry plate, developed by any method.

No. 1 shows a print on silver iodide paper in the presence of free silver nitrate.

No. 3 shows a print on silver bromide paper in the presence of free silver nitrate.

No. 5 shows a print on silver chloride paper in the presence of free silver nitrate.

No. 7 shows a print on silver bromo-iodide paper in the presence of free silver nitrate.

No. 10 shows a print on silver chloro-iodide paper in the presence of free silver nitrate.

The reader should note the limited range of the silver iodide, and even more so of the silver chloride. There is also a remarkable fact in connection with silver bromo-iodide and silver chloro-iodide. When exposed wet, these salts combine the sensitiveness of the two salts; but when exposed dry, the bromine or chlorine liberated by the action of light destroys the sensitiveness in that region of the spectrum (near G) in which the effect on the iodide is most marked. This is probably caused by the bromine or chlorine attacking the sub-iodide. Thus—

$$\underset{\text{Silver Sub-iodide}}{Ag_2I} \quad \underset{\text{and}}{+} \quad \underset{\text{Chlorine or Bromine}}{Cl \text{ or } Br} \quad \underset{\text{gives}}{=} \quad \underset{\text{Silver Iodo-chloride or Bromide}}{Ag_2ICl \text{ or } Ag_2IBr}$$

This has an important bearing on the dry plate process, in which such mixtures are to be found, and will be referred to in another chapter. The writer has made quantitative determination of the sensitiveness of different compounds to the spectrum, the method of obtaining which will be better understood when the subject of photometry is considered.

A fact to remember is that the action of light on a sensitive salt of silver is increased by heating the silver compound * during exposure. The effect of the heat is to cause the halogen to be more readily liberated than when the haloid salts of silver are cool, and the effect of cold is to retard the liberation of the halogen rendering the salt less sensitive. (See *Camera Club Journal*, 1895.).

We must here say a word regarding the ordinary action of light on silver salts which are dyed with certain dyes, on which orthochromatic photography, as it is called, depends. The law which is known as the conservation of energy requires that chemical action in a substance can only be effected by those rays of the spectrum which it absorbs. Thus, on page 8, the curves given of the darkening of the different salts of silver in various parts of the spectrum are a rough indication of the amount and kind of coloured rays which they absorb, more or less completely. Now, not only may these haloid (bromide, iodide, and chloride) salts of silver, but many other organic silver compounds, be changed by the action of light. There are certain dyes which can combine with silver nitrate to form organic salts of silver, a typical one being eosine, which is an organic bromide salt. When viewed in the spectrum, it is found that this salt absorbs the green rays. On exposing a plate coated with a mixture of this organic salt of silver with one of the haloid salts to the spectrum, it is found that, on development, a deposit of silver is precipitated exactly on that part where the green rays fell, together with a deposit on those parts where the part of the spectrum fell to which the haloid salt is sensitive. Thus, suppose the compound was a mixture of silver chloride and "eoside of silver," we should have, besides the curve 6, fig. 2, a small mountain lying between F and D. If silver iodide were mixed with the eoside of silver, we should have the same mountain in the green, together with that shown in curve 2, fig. 2. That this is the case may be seen by fig. 3.

It is not only silver nitrate, however, which will combine with the dyes. By use of ammonia, which acts as a partial solvent of bromide and chloride of silver, a compound of the bromide or chloride of silver with the dye can be formed, which may be a mechanical compound or lake. The part of the spectrum absorbed by this compound when it exists is not

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* *Photographic News*, May 1884.

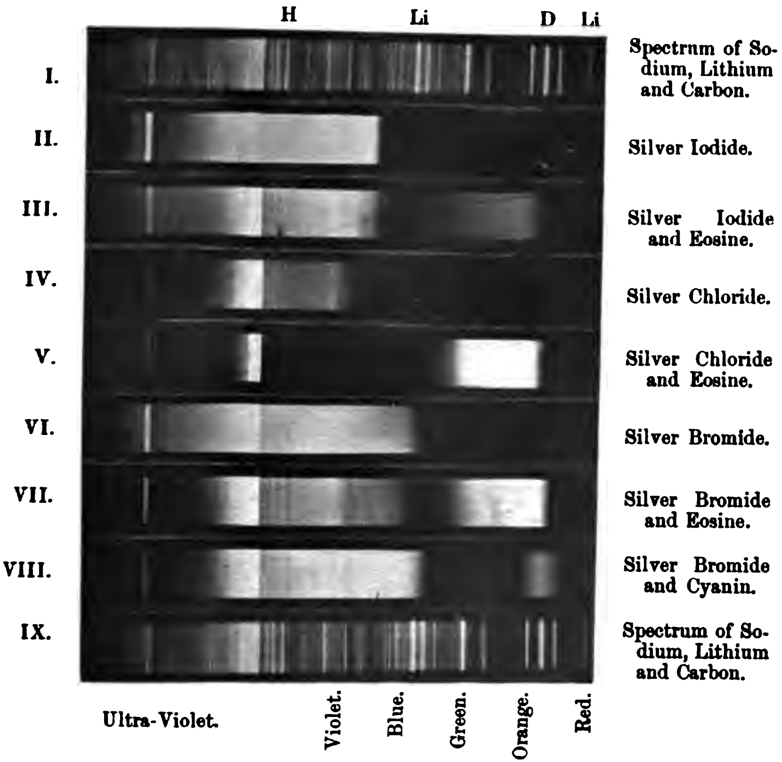


Fig. 3.

I. Spectrum of Sodium, Lithium and Carbon.
II. Spectrum on Silver Iodide.
III. Spectrum on Silver Iodide and Eosine (with excess of Silver).
IV. Spectrum on Silver Chloride.
V. Spectrum on Silver Chloride and Eosine.
VI. Spectrum on Silver Bromide.
VII. Spectrum on Silver Bromide and Eosine.
VIII. Spectrum on Silver Bromide and Cyanin.
IX. Spectrum of Sodium, Lithium and Carbon.

To face p. 10.

very different to that found when the dye combines directly with silver nitrate; hence the result is nearly the same in both. Again, we have another class of dyes which, by themselves, are very readily acted upon by light: cyanin blue is the representative of this class. Paper coloured with this dye, and placed in the spectrum, rapidly bleaches in the yellow rays. If a haloid salt of silver, held *in situ* in collodion or gelatine, be dyed with this colouring matter, it is found that, in addition to the ordinary sensitiveness of such a haloid salt, there is a sensitiveness shown in the yellow. As this dye does not combine with the silver itself, the development of an image is due to a secondary action, by which the dye during its alteration reduces a minute quantity of silver, to act as a

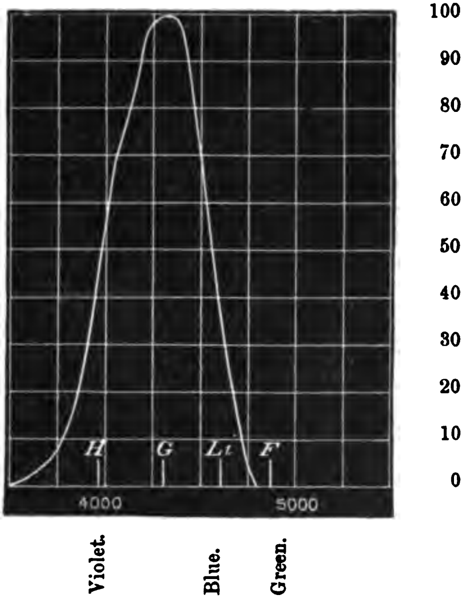


Fig. 4.

nucleus on which pure silver can be deposited. That the silver salt is not itself acted upon is shown by the fact that if we use bromide of silver as the dyed silver salt, and place it in the spectrum, a blackening takes place in the parts indicated in VI. fig. 3, and shown diagrammatically in the curve No. III. on page 340, but only a bleaching action in the yellow. This is not all, for if a collodion film be stained with this dye, and be bleached in the yellow of the spectrum, it is possible to deposit silver on this place, by coating it with a film of silver salt, and developing it. If it were the salt of silver that was acted upon, we should expect a darkening in both places. Fig. 3 gives diagrams of the effect of eosine and cyanin as estimated by the eye on the different salts of silver.

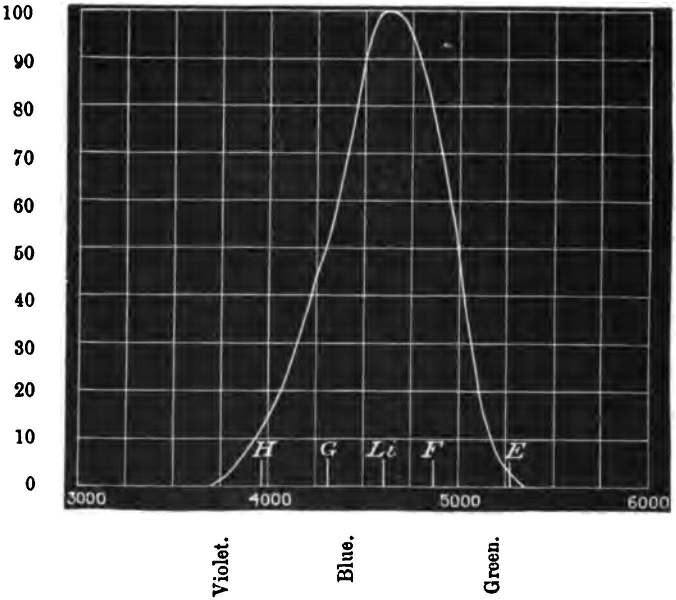
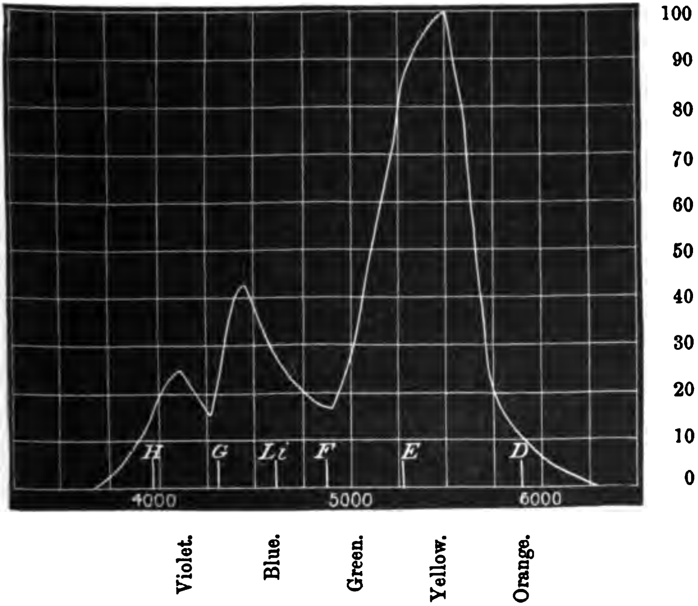


Fig. 5.

It must be remembered that white light only effects a chemical change in a compound because, of its constituent rays, some are effective; and it is because the red and orange glass, as a rule, cuts off all rays chemically active (actinic) on the silver compounds ordinarily employed, that coloured glass of these hues is used in our developing rooms, the light admitted through such glass being incapable of producing any primary change on them. It will be seen further on that some of these non-actinic rays may absolutely destroy the developing power of the substance acted on.



AgBr stained with erythrosin.

Fig. 6.

It may be as well to give here, and without comment, the relative sensitiveness of various kinds of plates to the different parts of the spectrum, merely saying that they were obtained by the methods described in Chap. XIII. p. 140.

It should be noted that the height of the curve above the base is the measure of sensitiveness to the different rays.

Fig. 4 shows the sensitiveness of silver bromide in collodio-bromide emulsion. It will be seen that it shows very little sensitiveness to the green.

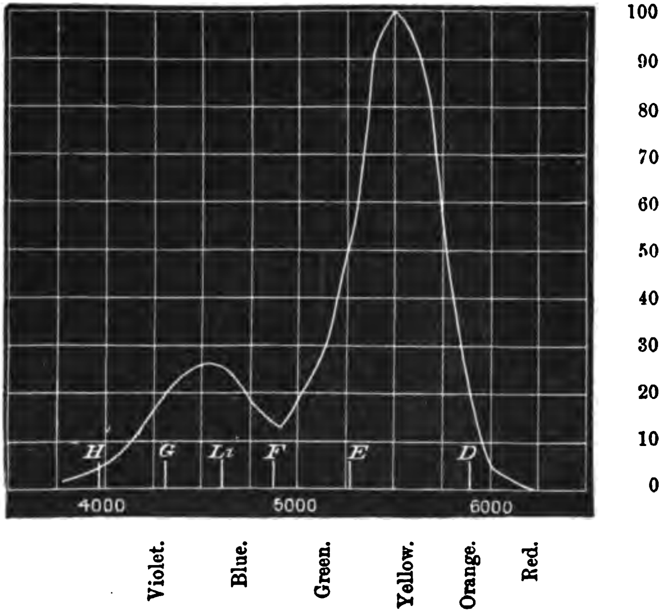


Fig. 7.—Edwards's isochromatic.

Fig. 5 shows a bromide of silver in gelatine having 4 per cent. of silver iodide mixed with the bromide before emulsifying.

Fig. 6 shows a gelatino-bromide plate stained with erythrosin. The excess of sensitiveness to the green is very marked.

Fig. 7 shows the curve of sensitiveness of an Edwards's isochromatic plate. It greatly resembles the curve in the previous figure.

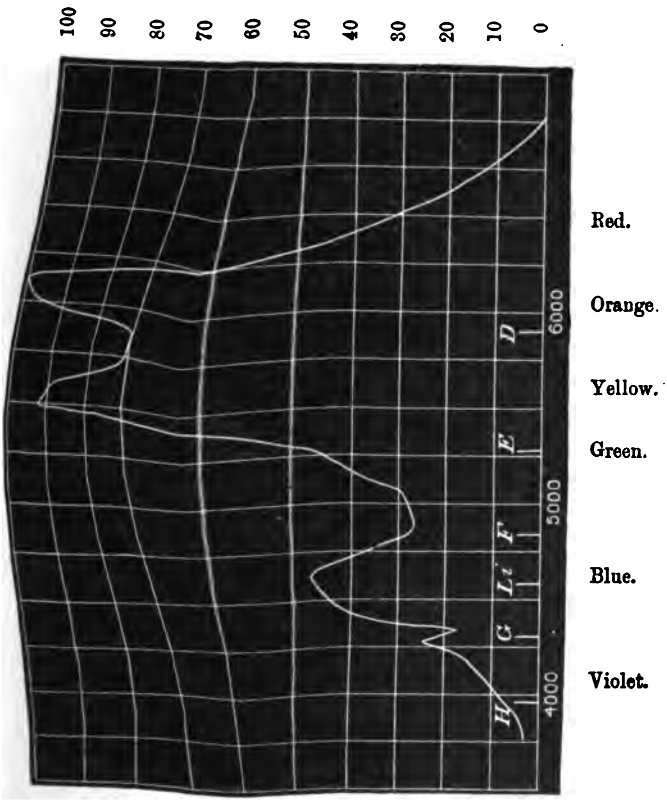


Fig. 8.—Edwards's isochromatic treated with cyanin.

Fig. 8 is remarkable as showing the increased sensitiveness of an ordinary isochromatic plate treated subsequently with cyanin. The orange and red sensitiveness is very well shown.

Fig. 9 shows the latest form of isochromatic plate, viz. Cadett's rapid spectrum plate. The curves are more regular than the others, and show that the want of action in the green is less felt than in the other kinds of plate. It is an exceedingly rapid plate where no screens are employed.

All these spectra photographs were taken with lamp-light; had ordinary daylight been employed as the source with which the spectrum was formed, the apparent sensitiveness to the blue would have been much more pronounced. The curves for sunlight or sky-light could be readily re-constructed by using fig. 24, page 46.

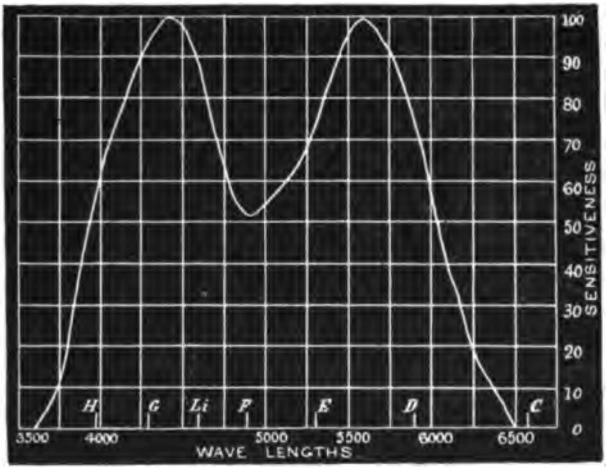


Fig. 9.

It should be noted that H is the violet limit of the spectrum, G is in the violet, Li in the blue, F in the blue green, E in the green, D in the orange, C, B, and A in the red of the spectrum. The numbers at the base of the curves show the wave-lengths of the colour.

CHAPTER III

THEORY OF DEVELOPMENT

What is technically called a "developer" is that agent which brings the minute chemical change effected by light to the cognisance of our senses. Development may be of such a kind as merely to alter the colour of the light-affected particles, or to build up a deposit upon some few that may have been altered. In the first case, it is evident that the action of light must be, however, very much prolonged to obtain any appreciable result; whereas, in the second, the impact of light may have been of very limited duration. The first we may dismiss from our minds when dealing with silver salts and camera images, and we need only concern ourselves with the second. We may divide developers into two classes—one in which the image is built up from matter external to the film, and the other in which it is built up from matter within the film itself. We will deal with the first class, to commence with.

Acid Development.—Pyrogallol, or, as it is generally but incorrectly termed, pyrogallic acid, is a body which is well known for its affinity for oxygen, as are the ferrous salts, these latter being changed to the ferric state—that is, they combine with more oxygen. When the oxidation of these bodies takes place in the presence of silver nitrate, silver is deposited. We will take the example of the iron salts when applied to the latent image to see how development is effected. The theory is based on the assumption that silver sub-salt, such as the sub-iodide Ag_2I, has an attraction for freshly-precipitated metallic silver, which is consequently deposited upon those parts acted upon by light. If to a solution of silver nitrate be added a solution of ferrous sulphate, the reaction that takes place is this. In the formulæ for wet-plate developers, silver is deposited, and ferric sulphate and ferric nitrate are formed. This, by chemists, is put in the form of an equation: thus—

$$\overset{\text{Silver Nitrate}}{6AgNO_3} \overset{\text{and}}{+} \overset{\text{Ferrous sulphate}}{6FeSO_4} \overset{\text{give}}{=} \overset{\text{Silver}}{6Ag} + \overset{\text{Ferric sulphate}}{2Fe_2(SO_4)_3} \overset{\text{and}}{+} \overset{\text{Ferric nitrate}}{Fe_2(NO_3)_6}$$

It will be noticed, however, that the addition of (acetic) acid is invariably included in wet-plate developers. If to a solution of pure ferrous sulphate (or of pyrogallic acid) a solution of silver nitrate be added, there will be an almost instantaneous deposit of metallic silver. If, therefore, the former solution were flowed over an exposed plate which had a solution of nitrate of silver on it, an immediate precipitation of silver would take place all over the film. The attraction of the sub-iodide of silver would be rendered void, owing to the rapidity of deposition. With an acidified solution, however, the deposition would take place with greater regularity and less rapidity, and when sufficiently slow, the sub-iodide would be able to attract all the particles of metallic silver as they were formed, and thus build up a metallic image. Hence the term, acid development. In practice the acid added is just sufficient to regulate this reduction of the silver. Not only is acetic acid effective, but nitric acid, sulphuric acid, citric acid, and, in fact, most of the organic acids, are so. Acetic acid is selected on account of its mild restraining power, and a consequent finer deposit. Since heat increases the rapidity of chemical action, it follows that a larger quantity of acetic acid must be used in hot than in cold weather.

Not only do acids restrain the reduction of the silver nitrate, but viscous matter is also capable of giving a physical restraint to the rapidity of the chemical change. Thus if pyrogallic acid be dissolved in water to which twice the bulk of glycerine is added, the reduction of silver will take place very slowly, or, at least, sufficiently slowly to allow an image to be developed.

A little consideration will show that when development takes place as above, the image must be principally *on the surface of the film*, and not in it. Experience shows that such is the case. In some cases the silver may be absolutely rubbed off with the finger.

It will also be noticed in the different formulæ for developing solutions for wet plates, that different quantities of the iron salt are given. The stronger the iron solution, the greater chemical power it will have, and the more rapidly it will decompose the silver solution. Consequently, with a strong solution, all parts of the picture acted on by light will immediately become nuclei for the deposition of silver, and the deposit will be of more even density than if a weaker solution had been employed; for with the latter, those parts most acted upon by the light —*i.e.* which had been most thoroughly converted into subiodide — having the most attractive force, would draw the deposit of silver to them, and the image would be much more intense at those parts than where the light had less strongly acted.

*Alkaline Development.**—With dry plates, and sometimes with wet plates which have been thoroughly washed from all silver nitrate,† there is another system pursued of developing the invisible image, known as "alkaline development." The silver compound to which it is usually applied is the bromide, though both the chloride and iodide can be rendered amenable to it by taking certain precautions which need not be enumerated here. Taking, as an example, silver bromide as the salt on which the image is to be developed, and pyrogallic acid rendered slightly alkaline by ammonia as the developer, we will trace what happens. When silver bromide is exposed to light, we have the formation of a certain small quantity of silver sub-bromide. If plain pyrogallic acid be applied to this, it will be found that scarcely any developing action is shown, even after prolonged contact; but that if a drop of weak ammonia be added, a blackening of the exposed parts at once takes place, and analysis shows that metallic silver has been formed.

Now, the silver sub-bromide is itself a dark-coloured body, but if the exposure be so short as to produce no visible discolouration, yet blackening by the developer wherever the minute quantity has been formed will take place, which indicates that not only those particles which are acted upon by

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* Major Russell first brought it into proper working conditions in 1862. It seems, however, to have been first used earlier, and probably unconsciously, by earlier workers, amongst whom was Mr. Leahey.

† Silver nitrate is at once reduced to the metallic state by alkaline development. Both alkaline and organic iron development are only suitable where the silver salt is a solid, and not in solution.

light get reduced, but that those adjacent to it are in some way affected. Experiment* has shown that silver bromide does not exist in molecular contact with freshly-deposited metallic silver, hence the moment the silver sub-bromide is attacked and reduced to the metallic state, at once fresh silver sub-bromide is mechanically formed by the combination between the metallic silver and the silver bromide, thus—

Silver	and	Silver Bromide	form	Silver Sub-bromide
Ag	$+$	$AgBr$	$=$	Ag_2Br

This new sub-bromide, in its turn, is ready for reduction by the developer. Now experiment also proves that silver sub-bromide is more readily attacked by the alkaline solution than the ordinary bromide, and this we should expect from theoretical reasoning, for evidently it requires more work to be expended to separate two atoms of bromine from the silver atoms than it does to separate one; hence we can trace the reason of the possibility of a developed image. In the formulæ with pyrogallic acid, it will be noticed that a soluble bromide is recommended to be added to the solution of pyrogallic acid and ammonia. This is to check the reduction of the unaltered silver bromide, the soluble bromide seemingly forming a compound with it, which is much less attackable by the developer.

The action of the alkaline pyrogallic solution is as follows, the used developer having been analysed † as to its constituents:—The silver bromide is split up into silver and bromine, which last is at once absorbed by the ammonia to form ammonium bromide, and probably a more complex compound, and the oxygen of the ammonia combines with the pyrogallic acid, some intermediate actions taking place. Chemical analysis also pointed out that a weak solution of alkaline developer reduces less silver sub-bromide than a stronger one. In every-day practice this is found to be the case; for an image developed by strong solutions is—at first, at all events—always more intense than that developed by a comparatively weak one.

Development by Organic Ferrous Salts.—Another class of developers which act similarly to the alkaline developers are

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* For a fuller account of this, see the *Photographic Journal*, 1877.

† *Photographic Journal*, 1877, and *Philosophical Magazine*, Jan. 1877.

the organic ferrous salts,* such as the ferrous oxalate, and we can trace in them more readily the action that takes place :—

Ferrous Oxalate	and	Silver Sub-bromide		give
$3(Fe,C_2O_4)$	$+$	$2Ag_2Br$		$=$
Ferric Oxalate	and	Ferrous Bromide	and	Silver
$Fe_2,(C_2O_4)_3$	$+$	$FeBr_2$	$+$	$4Ag$

By which it will be seen that a metallic bromide is formed, together with ferric oxalate.

It will be shown in another chapter that ferric oxalate destroys the developable image ; hence it is a retarder. Ferrous bromide is also a greater retarder of development than the potassium bromide. The writer has shown that the addition of a small quantity of hyposulphite aids development with the ferrous oxalate, and that a plate requires less exposure when using it. Let us trace what happens first as regards the ferrous bromide formed :—

Sodium Hyposulphite	and	Ferrous Bromide	give
$Na_2S_2O_3$	$+$	$FeBr_2$	$=$
Hyposulphite of Iron	and	Sodium Bromide	
Fe,S_2O_3	$+$	$2NaBr_2$	

Whence it will be seen that the extra retarding influence of the ferrous bromide vanishes, and the milder retarding sodium bromide is formed. Again, if we trace what will happen when sodium hyposulphite is added to ferric oxalate, we shall find that ferrous hyposulphite and ferrous oxalate are formed, and also a sodium oxalate. Dr. Vogel believed that the good effect of the hyposulphite is due to the hyposulphite of iron formed. It seems almost more likely that the destruction of ferric salt immediately on its formation is the great cause of the acceleration of development.

The reader may have gathered that with alkaline development, or with the ferrous oxalate development, there is a tendency for the image to spread laterally as well as down through the film, and microscopic measurement has amply proved this. The lateral spread is not sufficient, however, to be any drawback, except in the case of photo-micrographs. An interesting experiment † to make is to expose a dry plate in the camera, and afterwards to coat half of it with a film of

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* Mr. Carey Lea and Mr. W. Willis introduced this method of development almost simultaneously. See *British Journal of Photography*, 1877, page 293.

† See *Photographic Journal*, 1881, page 22.

collodion emulsion. On development by the alkaline or ferrous oxalate method, it will be found that the image is fed, as it were, from the top film; and that if two films be separated, the image will be on both. This is an experiment which explains more of the theory of alkaline and organic iron developments than any other with which the writer is acquainted.

CHAPTER IV

THEORY OF INTENSIFICATION AND FIXING

Intensification.—Any method of increasing the opacity of the developed image to the chemically active rays, either by changing its colour, or rendering the deposit thicker, is technically called "intensifying a negative," * and the agents used are called "intensifiers."

With collodion films either pyrogallic acid or ferrous sulphate may be employed with a solution of silver nitrate to increase the density by thickening the deposit of the metallic silver. The reactions here are analogous to those of development, except that the metallic silver is the attractive matter instead of the sub-iodide. As the silver is gradually reduced to the metallic state, it is deposited on the silver already reduced by the action of the developer.

There are other methods of increasing the deposit, such as treating the deposited silver with mercuric chloride, to form a double salt of mercury and silver, and a change may take place in the colour, as well as in the density of the deposit. Change in colour may be produced by substitution; as an example, if we treat the developed image in collodion with gold tri-chloride, we shall have the following reaction :—

$$\underset{\text{Silver}}{3Ag} \;\text{and}\; + \;\underset{\text{Auric Chloride}}{AuCl_3} \;=\; \underset{\text{give deposited Gold}}{Au} \;+\; \underset{\text{and Silver Chloride}}{3AgCl}$$

In other words, the gold displaces the silver. The equation, however, indicates that the image would be weakened in density, as one atom of gold takes the place of three of silver.

In the formulæ for intensification, there are several given in

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* Manifestly, adding to the thickness of the deposit of a print is useless. The colour may, however, be changed, in which case the action is termed "toning," and not "intensifying."

which different metallic salts are used to produce the change. We will now (theoretically) explain one or two of these. It will be seen, for instance, that potassium bromide and cupric sulphate * are applied to the silver image, which is then treated with silver nitrate. The reaction is as follows:—

Cupric Sulphate and Potassium Bromide form Cupric Bromide and Potassium Sulphate

$$CuSO_4 + 2KBr = CuBr_2 + K_2SO_4$$

In other words, this is a means of producing cupric bromide.

When cupric bromide is applied to metallic silver, we have—

Cupric Bromide and Metallic Silver form Cuprous Bromide and Silver Bromide

$$CuBr_2 + Ag = CuBr + AgBr$$

When silver nitrate is applied to the cuprous bromide, we have—

Cuprous Bromide and Silver Nitrate form Cupric Nitrate and Silver Sub-Bromide

$$CuBr + 2AgNO_3 = Cu(NO_3)_2 + Ag_2Br$$

Thus, on one atom of silver, another atom of silver bromide and one of sub-bromide are deposited. Again, Eder and Toth's ferrocyanide of lead intensifier is explained in this way: †—

Potassium Ferricyanide, Silver, and Lead Nitrate form

$$2K_6Fe_2Cy_{12} + 4Ag + 6Pb(NO_3)_2 =$$

Ferrocyanide of Silver and Lead Ferrocyanide and Potassium Nitrate

$$Ag_4FeCy_6 + 3Pb_2FeCy_6 + 12KNO_3$$

Again, when mercuric chloride is applied to metallic silver, we have the following formed:—

Mercuric Chloride and Silver form Calomel and Silver Chloride

$$2HgCl_2 + 2Ag = Hg_2Cl_2 + 2AgCl$$

If this is followed by the application of strong ammonia, we have the following formed:—

Calomel and Ammonia form Di-mercurous Ammonium Chloride and Ammonium Chloride

$$Hg_2Cl_2 + 2NH_3 = NH_2Hg_2Cl + NH_4Cl$$

When ammonium sulphide is used instead of ammonia, the calomel is split up into mercuric sulphide and finely-divided mercury, and the silver chloride is also converted into a form of silver sulphide. A very favourite intensifier is to use the mercuric chloride as above, and to develop with ferrous oxalate or ordinary alkaline developer, in which case there is left a mixture of metallic silver and mercury.

Fixing the Image.—After the development of the latent

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* *Photographic Journal*, 1877, p. 41.

† *Photographic News*, 1876, p. 123.

image or picture formed upon the sensitive film, the silver haloids are left unaltered.

Looking at the reverse side of the plate (that which does not bear the film), the yellow colour of these haloids or mixture of haloids of silver will be apparent.

Were the unaltered iodide and bromide left in the film, a print taken from such a plate would be found to be nearly a blank, as these bodies possess almost as much power of preventing the passage of light as the reduced silver itself. There are certain chemical compounds which, in solution, are capable of converting them into soluble compounds. When such compounds are applied, they leave the metallic silver unchanged. These solvents are termed *fixing agents*, and the operation of dissolving out the silver iodide and bromide is termed "fixing the image." Dismissing the chlorides of the alkalies and potassium iodide (owing to their imperfections as fixing agents), the solvents of iodide, bromide, or chloride of silver that are to be noticed here are sodium hyposulphite ($(Na_2S_2O_3)$),[*] and potassium cyanide (KCN or KCy).

The following is the chemical reaction of the cyanide on silver iodide:

$$\overset{\text{Silver Iodide}}{AgI} \overset{\text{and}}{+} \overset{\text{Potassium Cyanide}}{2KCy} \overset{\text{give}}{=} \overset{\text{Double Cyanide of Silver}}{AgKCy_2} \overset{\text{and}}{+} \overset{\text{Potassium Iodide}}{KI}$$

If bromide or chloride be substituted for the iodide, the same reaction occurs.

Potassium cyanide[†] has a slightly solvent power on finely-deposited metallic silver. If a test-tube be coated with a fine layer of metallic silver, it will be found that a strong solution of the cyanide will completely dissolve it after a short interval of time. From this simple experiment we learn the necessity of using a weak solution of this fixing agent, and allowing it to remain on the plate as short a time as possible, since the image is metallic silver in a very fine state of division, more particularly in the half-tones.

With gelatine plates the deposit is so fine that this agent

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[*] More correctly called the thio-sulphate.

[†] The potassium cyanide is a deadly poison, and great caution should be exercised in working with it. Its fumes are deleterious to the system, and if the solution come in contact with a cut or sore place in the skin, festering is liable to occur.

is generally avoided, though it may be used weak and with caution.

Most photographers recommend the hyposulphite of soda, in preference to the cyanide, as a fixing agent for negatives, owing to the latter's poisonous character and liability to eat into the half-tones. The colour of the negative given by the latter by reflected light is whiter, but by transmitted light browner, and, consequently, more non-actinic than if the former be used. If ordinary precautions are taken, cyanide need not prove hurtful to the operator through inhalation or otherwise; and if the films (such as a wet plate) which will stand cyanide be washed immediately after the haloids of silver are dissolved out, there need be no fear of an attack on the half-tones.

Great care should be taken that no acid come in contact with the cyanide solution, as it is decomposed, and hydrocyanic acid vapour (prussic acid) is given off. The vapour is almost more dangerous than the liquid solution.

In fixing prints, sodium hyposulphite is almost invariably used as the fixing agent, and a strong solution is necessary to secure permanency of the print. The reason of its use is, that cyanide will dissolve the silver oxide formed in the organic silver compounds used, whereas hyposulphite does so only slowly; and the reason why a strong solution of the latter should be used is, that there are said to be two silver hyposulphites which can be formed:—

$$\overset{\substack{\text{Silver}\\ \text{Chloride}}}{AgCl} + \overset{\substack{\text{Sodium}\\ \text{Hyposulphite}}}{Na_2S_2O_3} = \overset{\substack{\text{Double Hyposulphite}\\ \text{of Silver and Sodium}}}{AgNaS_2O_3} + \overset{\substack{\text{Sodium}\\ \text{Chloride}}}{NaCl}$$

and—

$$\overset{\substack{\text{Silver}\\ \text{Chloride}}}{2AgCl} + \overset{\substack{\text{Sodium}\\ \text{Hyposulphite}}}{3Na_2S_2O_3} = \overset{\substack{\text{Hyposulphite of}\\ \text{Sodium and Silver}}}{Ag_2Na_4(S_2O_3)_3} + \overset{\substack{\text{Sodium}\\ \text{Chloride}}}{2NaCl}$$

If silver iodide or bromide be substituted for the chloride, the same reactions will occur.

The first double hyposulphite is nearly insoluble in water; the last is highly soluble. These two salts may be formed for experiment: in the first case by adding an excess of silver nitrate to the sodium hyposulphite solution, in the other by adding a large excess of the latter to the former. With the first we have a dirty-brown precipitate; with the latter there will be a perfectly clear solution. The student is recommended to try the experiment.

CHAPTER V

PHENOMENA IN DEVELOPMENT

It is now proposed to enter briefly into certain phenomena which present themselves in the development of the photographic image.

It will be seen in the wet-plate process that it is necessary, 1st, to use a collodion which contains free iodine; and 2nd, to use a bath slightly acidified. Ordinary iodised collodion, such as is ready for use, contains a soluble iodide, a little soluble bromide, and rarely some chloride; and in the instructions issued with commercial collodions it will be seen that it is recommended to add tincture of iodine (iodine dissolved in alcohol) till it assumes a golden sherry-colour. Let us trace what will happen when such a collodion is immersed in the bath.

It is a known fact that if silver chloride is in contact with a soluble bromide, silver bromide will be formed, leaving a soluble chloride behind. Thus:—

Silver Chloride and Potassium Bromide

$$AgCl + KBr$$

give Silver Bromide and Potassium Chloride

$$= AgBr + KCl$$

Again, silver iodide will be formed if a soluble iodide be present with either silver chloride or bromide, or both. Thus, when a plate is coated with collodion, the iodide will first of all be formed, and then the bromide, and finally the chloride. The free iodine will at the same time also form iodide and iodate of silver, and liberate in the film a little nitric acid, thus:—

Iodine and Silver Nitrate give Silver Iodide, Silver Iodate, and Nitric Acid

$$6I + 6AgNO_3 = 5AgI + AgIO_3 + 6HNO_3$$

The question arises as to the use of this reaction. If we use potassium iodide in the collodion we shall find that, as a rule, it has an alkaline reaction, turning reddened litmus paper blue. Pure potassium iodide should be perfectly neutral, but it can well be understood how the alkaline reaction might arise. If, for instance, the iodide be slightly moist (moisture from the surrounding air is sufficient), we have then a body sensitive to light. Dr. Leeds has shown that the following reaction may take place :—

Potassium Iodide with Water and Oxygen give Iodine and Potash

$$2KI + H_2O + O = 2I + 2KHO$$

The iodine volatilises, and we have potash or potassium hydrate left behind. In this way, then, the iodide may be alkaline. Suppose, now, we have iodine added to such an iodide, we have the following :—

Iodine and Potash form Potassium Iodide, Potassium Iodate, and Water

$$6I + 6KHO = 5KI + KIO_3 + 3H_2O$$

The addition of iodine thus insures the absence of all alkalinity from a collodion. If it were alkaline, silver oxide would be precipitated, and would form a nucleus on which development would take place. Iodine thus secures freedom from what is called fog, which is a precipitation or reduction of silver in parts of the plate which have not been acted upon by light.

The next point is regarding the acidity of the bath solution. It may safely be said that if the collodion be in proper working order, no acidification of the bath should be necessary. It must not be forgotten, however, that proxyline is not always an innocuous substance; it sometimes contains matter which is liable to reduce silver nitrate to the metallic state, when the silver nitrate is absolutely neutral; if, however, the silver nitrate be acid, such a reduction is almost impossible. Again, too, by keeping in the presence of iodides and bromides and free iodine, one of the collodion solvents is apt to be partially reduced to the state of aldehyde, which reduces silver nitrate to the metallic state when in a neutral condition, and the small particles of silver so reduced would cause a veil. The addition of acid, particularly nitric acid, to the bath, entirely prevents this. Hence, for safety's sake, the silver bath should be just *not* neutral, but slightly acid.

When emulsions in gelatine or collodion are formed, the same reactions indicated above hold good; that is to say, fog or veil might be expected if the whole of the soluble haloid salts were converted into the respective silver haloids. Besides an alkaline reaction, however, it may happen that the salt employed contains portions which are not fully saturated with the halogen (iodine, bromine, etc.), in which case we should have the formation of a silver sub-haloid. Thus, with copper, the saturated bromide is cupric bromide ($CuBr_2$); it is sure to happen that cuprous bromide ($CuBr$) would also be present, in which case, on the addition of silver nitrate we should have the following:

Cuprous Bromide and Silver Nitrate form Silver Sub-bromide and Copper Nitrate

$$CuBr + 2AgNo_3 = Ag_2Br + 2CuNo_3$$

Thus, we should have the same salt formed chemically which is formed physically by the action of light on silver bromide, and again we should have fog on the development of plates prepared with such a compound. The question is, how can such be eliminated or altered so as to be non-injurious? Acid will do it, more particularly nitric acid, for then we probably get the following reactions:—

Silver Sub-bromide and Nitric Acid form Silver Bromide, Silver Nitrate, Nitrous Acid, and Water

$$4Ag_2Br + 6HNO_3 = 4AgBr + 4AgNO_3 \times N_2O_3 + 3H_2O$$

If hydrochloric acid be added, we have a simpler reaction, which is the formation of silver bromide and hydrogen. Another means exists of getting rid of the sub-bromide, which is to add iodine or bromine to the emulsion, forming a bromo-iodide of silver in one case, and bromide in the other. By adding an oxidising agent to it, we also eliminate the sub-bromide, or rather, render it undevelopable. Thus, we find that permanganate of potash, bichromate of potash, ozone, and peroxide of hydrogen destroy the sub-bromide as far as its developing powers are concerned, the exact reaction that takes place being somewhat uncertain. Again, any body which will readily give up a halogen is a certain eliminator of the evil arising from the chemically-formed sub-bromide. Thus, cupric bromide or chloride will give up an atom of bromine or chlorine to the silver sub-bromide.

Cupric Bromide and Silver Sub-bromide yield Cuprous Bromide and Silver Bromide

$$CuBr_2 + Ag_2Br = CuBr + 2AgBr$$

When, however, an adulterated soluble haloid (and when we say adulterated, we mean one which contains some adulteration which, when placed in silver nitrate, would cause the formation of fog or veil on a plate) has to be employed, and it is so managed that the silver nitrate is less than that required to convert both the haloid and its adulteration into a compound of silver, it will be found that the adulteration is last to be formed, and that the haloid will be pure. Thus, then, we have another plan to prevent the formation of the fog-giving salt of silver, by keeping the silver nitrate in defect. This is a most important proposition to establish, since the possibility of a gelatine emulsion depends on its application.

Both sides of the advisability of using an excess of soluble haloid must, however, be looked at. We have seen that potassium iodide will, in the light, liberate iodine in presence of oxygen, and this is yet more so the case when it is also in the presence of metallic silver, or an unsaturated compound of silver, such as the sub-iodide; and the action of light on potassium bromide under the same circumstances is precisely the same. And we have also seen that the silver sub-salt is destroyed by iodine or bromine. Suppose we have silver bromide and potassium bromide exposed to light together; then, as fast as the silver sub-bromide is formed, it has a tendency to be destroyed by the potassium bromide splitting up into bromine and other compounds; so that the real sensitiveness of the mixture depends on the difference in sensitiveness of the silver bromide and potassium bromide. It is thus evident that the sensitiveness must be less than when the silver bromide alone is present. There is another phenomenon with which this destruction of the sub-salts of silver, and, consequently, the destruction of the developable image, is connected; and that is, the reversal of the image, or *solarisation*, as it used to be incorrectly called. Reversal of the most aggravated type means the formation of a positive instead of a negative image on development. In the early days of photography with collodion, when merely iodide of silver was used on which to impress the developable image, this (apparently) strange phenomenon was often encountered. In a landscape negative, whilst the rest of the picture would have its proper gradations, the sky would appear as eaten out, and nearly a blank, with scarcely any deposit of silver, any small deposit taking a rather roseate hue. When bromide was added to the iodide, the defect was rarely met with in wet plates, though, in the case of interiors, when a window illuminated with bright light, and dark parts immediately near it, had to be portrayed on the same plate, the defect was still to be found. With collodion dry plates in which preservatives are used, the phenomenon was still more rare; but with gelatine plates its occurrence is by no means uncommon. Let us endeavour succinctly to show what is the cause of this. First, with wet plates; experiment has shown that sub-iodide of silver is more readily oxidised than the bromide, and it is for this reason that reversal was more frequently met with in the case of this salt than with the bromide.

When bromide is used as well as iodide, the nitric acid has a direct action on it; but when used in combination with the iodide, the sub-bromide formed by light may act as an absorbent of iodine when all the free silver nitrate is exhausted. When a proper preservative is used, in an alkaline condition more especially, it absorbs both iodine and bromine, and hence solarisation or reversal of the image takes place with greater difficulty. It must be remarked, however, that, to be effective, it is almost a *sine quâ non* that some moisture be present, as a thoroughly dry preservative can only very slowly combine with iodine. Any organic substance, when it combines with a halogen, does one of two things, as already pointed out in page 3. The one atom of the halogen takes the place of a hydrogen, and another combines with this hydrogen to form hydrobromic acid, or else the halogen takes the place of what is called a hydroxyl group (HO).

Hydrobromic acid is a strong destroyer of the developable image, and a preservative which helps to create it is likely to yield plates which will not keep unless some body be present to combine with it and render it innocuous—an alkaline carbonate, such as soda, will answer the purpose. This is the condition of most collodion dry plates; hence reversal with them is not common.

In a gelatine film, probably the bromine, when coming in contact with gelatine, liberates hydroxyl or peroxide of hydrogen. This, as is well known, is a very strong oxidiser, and it will oxidise the neighbouring molecule of gelatine, or else the silver sub-bromide, and so produces an undevelopable image. We need only point out that some such action as this must occur, since in a gelatine plate exposed to direct action of light so as to show a strong image, the gelatine becomes more insoluble in the parts acted upon by light than in those where no exposure has taken place.

This will readily account, then, for the reversal of the image in a gelatine plate. If a gelatine or other plate be soaked in potassium nitrite or sodium sulphite, each of which is a strong bromine absorbent, it may be exposed for almost an unlimited time, and no reversal will take place. The reversal of the image on a film supported on glass is of a much more aggravated character than when a paper support is used,

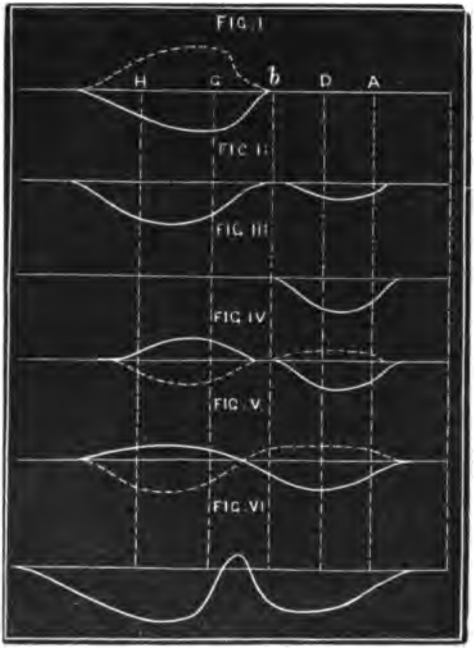

Fig. 10.

such as in Warnerke's gelatino-bromide paper. This is due to the fact of halation taking place at the same time, the halation forming a background on which the reversed image is more readily distinguished, and also the fact that there are two surfaces through which the bromine may escape instead of only one. As will be gathered from the beginning of the present chapter, a silver haloid precipitated in the excess of soluble haloid is more liable to reversal than one which is not so prepared, as the soluble haloid itself is sensitive to light. Not only are the rays which affect the haloid salts of silver effective in acting on the soluble haloid—such as potassium bromide—but also the red rays.

The diagrams on pages 32 and 34 (figs. 10 and 11), taken from a paper in the *Philosophical Magazine* by the author in 1880, will show what rays are active in causing reversal.

The dotted curves need not be regarded for the question now being discussed. The curves below the base show the destruction of the preliminary exposure by the subsequent exposure to the spectrum, the curves above show the increased action due to that exposure.

No. I. shows the action of a spectrum on a film containing silver iodide which had been exposed to light, and then treated with potassium iodide.

No. II. shows the same plate, only treated with potassium bromide, by which it will be seen that the red and yellow rays are active in causing reversal.

No. III. is the same plate when exposed to the spectrum in the presence of potassium bichromate. Here we have the red and yellow rays only active.

No. IV. shows the same plate exposed with permanganate of potash present; and—

No. V. shows it when exposed in the presence of hydroxyl (peroxide of hydrogen); while—

No. VI. shows the action of mineral acids on silver iodide during exposure. We next come to the bromide films.

No. VII. shows the action of the spectrum on a bromide film —after being exposed to light—in the presence of potassium bromide.

No. VIII. is the same plate, but exposed in an alkaline solution of potassium bromide.

Nos. IX. and X. show the effect when the bromide is exposed in the presence of potassium permanganate and of potassium bichromate respectively.

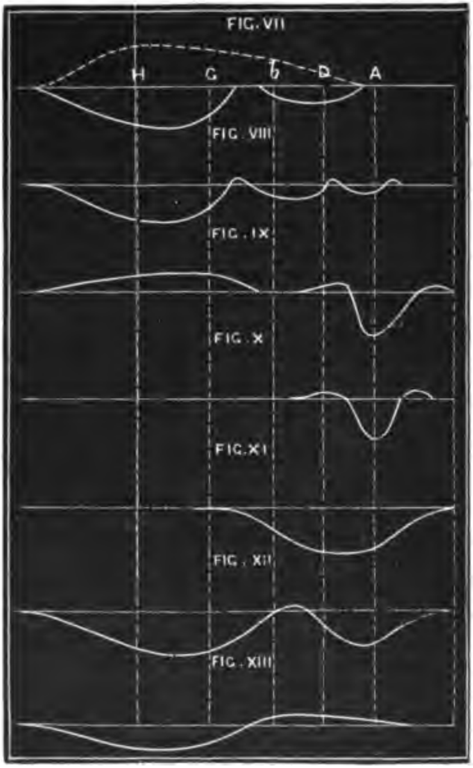

Fig. 11.

No. XI. shows the action on a gelatine plate when exposed in the presence of the bichromate.

No. XII. shows the effect of mineral acids (such as nitric acid) in causing reversal.

No. XIII. shows the ordinary reversal of the image on a gelatine plate.

A study of these figures will repay the reader who is interested in knowing the why and the wherefore of this strange phenomenon, and it will be apparent that not only have the blue rays to be reckoned with, but also those rays which are usually supposed to have no chemical effect. In both diagrams the depth of the curve below the horizontal line shows the intensity of the reversal, the heights above the line showing the ordinary negative image. The dotted curves show variations in the phenomena by varying the exposure. It may be mentioned that the writer has, on several occasions, demonstrated the reversing action of the red rays in the following manner. A white screen was illuminated by a feeble white light, and on this screen was thrown a disc of red light, being the image of a circular aperture in front of an electric light covered with stained red glass. A collodion emulsion plate, or a wet plate, exposed to photograph the white screen with this red disc, showed the white screen as dense in the negative, but the red disc as nearly transparent. It must be recollected that the *whole screen* was illuminated with the same white light, the red light only being superposed over it. If the red rays had no reversing action, the screen should have come out of equal density throughout on the negative. When the red disc was thrown on the plate without any white illumination, there was no developing action, showing that the reversal was not caused by over-exposure.

CHAPTER VI

THE PHYSICAL PHENOMENA IN SENSITIVE FILMS, INCLUDING HALATION

THE reader may so far have not formed any concise idea of what a sensitive film in collodion or gelatine really is. It is too often considered as if it were a homogeneous layer of collodion or gelatine and silver salt mixed. An examination under the microscope when properly made will, however, reveal that it is something totally unlike this. When magnified some hundred times, both films are seen to be uneven and granular, indicating that the sensitive salt is not continuous, but separated more or less by intervening collodion or gelatine. (See fig. 12.) A still further microscopic examination made by cutting very fine vertical sections of the film reveals this granularity still more. A collodion film is found to be much more compact than the gelatine film; the sensitive salt in the former seems to be an aggregation of small lumps, whilst in the latter it is a regular network of filaments of the silver salt, separated by equally fine or finer filaments of gelatine. (See fig. 13.)

Probably the greater bulk of the granules in the collodion film than in the gelatine explains the reason of the greater sensitiveness of the latter over the former. A ray of light striking the larger particles can only penetrate some small way into them, and a comparatively small number of molecules are altered by the brief impact of light. (See fig. 14.) In a gelatine film, on the other hand, the surface of silver salt exposed to a ray of light which has a certain section, is many times that of the grosser particle, and consequently more molecules of the sensitive salt are decomposed and produce nuclei on which development takes place. The light penetrating through the

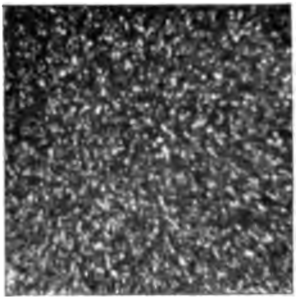

Fig. 12.—Photo-micrograph of a photographic film.

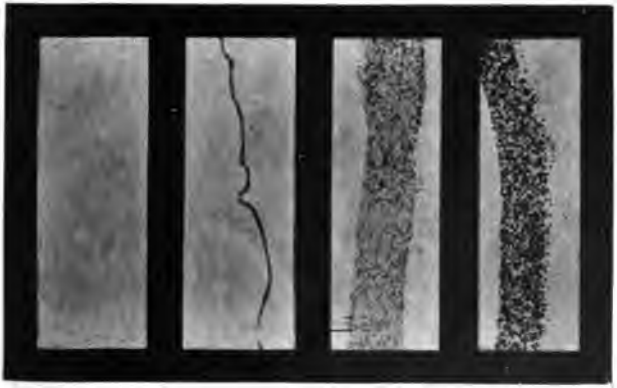

Fig. 13.—Photo-micrograph of sections of photographic films.

Fig. 14.—Photo-micrograph of sections of collodion and gelatine films.

To face p. 36

film may be the same in the two cases. But much of the useful energy in the one is lost, whilst in the other it is utilised. It must also be suspected that gelatine is a sensitiser (see page 31), and is also in intimate contact with a large surface of the silver salt. The collodion is not a sensitiser, and on this account must remain neutral, and is not used in the decomposition of the molecules of silver salt as explained in previous chapter. After development the whole aspect of the film is changed, as shown in the figures.

The surface is seen to be composed of grains of silver, very minute, it is true, and not being more than one billionth of an inch in volume. The vertical sections show that in the collodion the grains are closer together, but not more in number, whilst in the gelatine film they are well separated one from the other. We can now see from what the density of a film is derived. It is evident that light endeavouring to pass through a film, has to struggle against the obstruction of the grains, and finds its way through the interstices only, some small quantity being reflected from grain to grain. It is a law in physics that light travelling through particles loses intensity in a given ratio. The light transmitted is in a geometrical ratio. If there are 100 particles of the same size and, say, 50% of the light is transmitted, then if there are 200 particles only a quarter of that light would pass through them, or 12½% of the original light. Carefully counting up these particles in a given area of a section, this was found to be true within proper limits of error. The developed image is not therefore a very simple matter to deal with, as owing to these particles a certain amount of light must be scattered as it passes through the film. Notoriously a film appears more opaque when used at a distance from a printing surface, as it is in enlarging or camera printing, than it does in contact with it, as it is in the ordinary printing frame. This extra opacity may be traced to the fact that the lens will not collect all the light which passes through the film; most of the scattered light being lost. In a subsequent chapter it will be found that a sensitive film of ordinary thickness does not impede the passage of all photographically active light through it, though it is much diminished after its passage through it.

In the last chapter we gave a reason for reversal of the image. In considering the evidence to support the theory there given, the writer showed at the Camera Club in 1897 that at the top of the film where reversal had begun, the grains of reduced silver were smaller than at the bottom of the film next the glass, although the number of grains per unit area of the section remained the same. (See fig. 15.)

From this it may be deduced that the particles of bromide of silver become less capable of being reduced to the metallic state than when the exposure is normal, and this points to the truth of the theory propounded. In the foregoing figure the bottom rectangle contains a microphotograph of lines ruled on a glass surface, about 6000 to the inch in the original. This gives an idea of the scale of magnification, and of the absolute thickness of the gelatine and collodion films.

Halation.—One of the phenomena met with in photography is a blurring of the image; for instance, in a landscape an encroachment of the high lights on a darker portion next to it will take place. In photographing interiors of buildings, in which there is often a bright light streaming through a window, this effect is markedly seen, as also when exposing a plate in the direction of the sun, where the direct rays enter the lens.*

Halation is really caused by reflection from the back of the glass plate. Rays of light entering a film are scattered by the particles of the silver salt, and obey certain well-known optical laws. Suppose S (fig. 16) to be a magnified image of a grain of the silver salt lying on the glass plate G. Let A, B, and C be three of the rays falling on S. They will each be reflected according to the ordinary laws of reflection. A, which falls on the top of the grain, will be reflected vertically back. B will be reflected to *m*, the top surface of the glass, and be refracted to *n*, and will be totally reflected from *n* to *o*, where another particle, S′, may be situated; B, by reflection, will then act on S′. The ray C will be reflected immediately between S and S′ to *p*, and will be refracted to *q*. Part will pass out to *t*, and part be reflected to *r*, where another grain of silver (S″) may be situated, and, therefore, the ray C will

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* The subject has been investigated by the writer on two occasions—once in 1875, when treated mathematically in the *Philosophical Magazine*, and again in 1881, in a more popular manner, before the Photographic Society of Great Britain.

Fig. 15.

To face p. 38.

Photo-micrograph of developed films.

also act on S″ as well as on S. This will be the case, although no direct rays fall on S′ and S″.

More rays are reflected back at what is known as the critical angle of the glass than at any other part. For this reason a dot will be surrounded by a circle of great intensity, where the rays are reflected at the critical angle, shading off towards the centre and to the outside (fig. 16*a*). A line will show a halo (as in fig. 16*b*), and this can be shown to be built up of a series of circles (fig. 17). A cross can then be traced to the figures surrounding two lines at right angles (fig. 18). Again, by increasing the thickness of the plate, the figure is seen to be extended (fig. 19), as should be the case as required by theory. The image of a disc will be surrounded by a halo encroaching up to its edge, and this, again, can be shown to be built of a series of circles formed by every point in the disc, as can the image of a triangle (fig. 20).

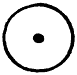


Fig. 16*a*.

Fig. 16*b*.

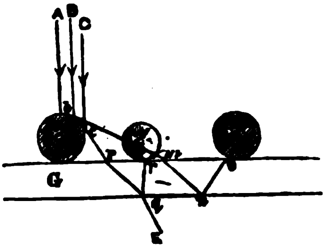


Fig. 16.

It will thus be seen, if we can get something which will not reflect at all, or which will only reflect rays which are chemically inactive on the salts of silver, that such halation can be done away with entirely. In some dry-plate processes, it will be noticed that what is called a backing is recommended to be used, and the sole reason for its use is that the reflection from the back of the plate is, at all events, lessened. The great desideratum in a backing is, that it should reflect none—or, at all events, only inactive rays—and that it should be in absolute (optical) contact with the back of the plate. It should also, as nearly as may be, have the same index of refraction for the rays which have to be absorbed as the glass itself. Caramel or sepia and burnt sienna mixed with gum will be found fairly effective, but perhaps asphaltum is as nearly a perfect backing as may be found.

In the previous chapter we remarked that the reversal of the image appeared to be aggravated by halation, and it will now be seen for what reason. The scattered light, after passing through a film, is much reduced in intensity. It therefore follows that the time necessary to cause a reversal of the halation is vastly greater than that necessary to cause a reversal of the actual image. Thus we get the feeble image caused by reversal, lying on a background which is not at all, or only slightly, reversed. Of course, when proper backing is used, there is no reflection, and the reversal is less evident. We may also here remark, that in a paper negative, no reflection can take place, except a *very* slight one in the film itself. As the extent of the halation depends on the thickness of the film in paper negatives, the halation is practically *nil*. In the case of a paper negative, also, the halogen liberated by light has two surfaces from which to escape, and consequently there is, on this account, less chance of reversal taking place.

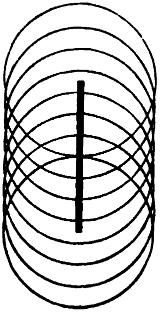


Fig. 17.

Fig. 18.

The more absolutely transparent a film is, the less chance there is of blurring, since the particles seem not to be of sufficient size to scatter the light. It should be noted, that in some collodion dry-plate processes, the preservative used has a tendency to cause halation, which is due, in a great measure, to the action of the preservative itself—that is, the particles of the preservative scatter the rays; whilst, with the same film, another preservative would entirely do away with the necessity of any backing whatever. With a wet plate, the particles of liquid lying in the film scatter the light and give rise to halation; but the emulsion processes are those which are most prone to show it in its worst form. An exact estimate of the amount of blurring that may be expected may be formed by cutting out in tinfoil a straight line of about one-fiftieth of an inch in width, and then placing it in contact with the film on the prepared plate. If the line be looked at through the film in a moderately bright transmitted light, it will be seen surrounded by a halo (as in fig. 16*b*), bright in exact proportion to the amount of rays scattered by the film.

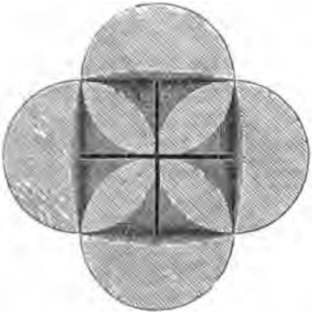


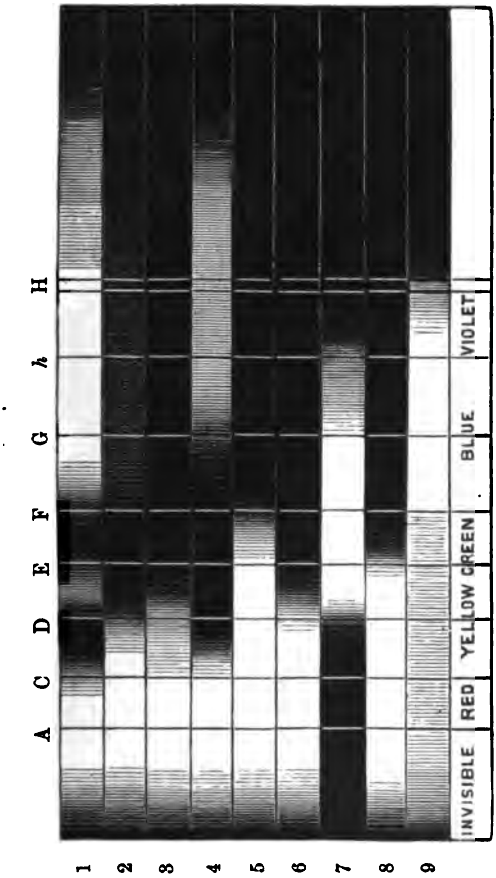
Fig. 19

Fig. 20.

CHAPTER VII

THE DARK-ROOM AND ITS FITTINGS

Illumination of the Dark-Room.—In considering the subject of the dark-room, the purpose for which it has to be used must be taken into account. Perhaps the most important point is the consideration of its illumination. A little reflection will show that this depends entirely on the kind of work which has to be undertaken in it. Thus, a reference to Chapter I. will show that for the wet process the light may be of such a colour that all the rays from the red to the green may be allowed for illumination; whilst with a gelatino-bromide plate no visible rays are absolutely safe, but that those from the orange to the red (D to A) will have least effect, and that the more the light is confined to the lower end of the spectrum, the safer it will be. For silver chloride even the blue rays might be admitted, as well as the green, yellow, and red. Figure 21, on page 43, shows the light which passes through different glasses and dyes. Looking at No. 5 it will be seen that, for wet-plate work, when bromo-iodide of silver is used, it is a safe light; whilst for pure ordinary bromide, No. 6 would answer. For bromide as formed in gelatine plates, neither the one nor the other would be admissible. In this case a combination would have to be made, and this might be a combination between Nos. 2 and 6, for the hurtful light which would pass through the one is cut off from the other. Again, a combination between No. 8 or No. 3 and No. 4 would equally answer, or between No. 6 and No. 4. A caution is here necessary. Dyes are affected by light bleaching to a very considerable extent. If, therefore, the windows of the dark-room be covered with dyed paper, or with dyed varnish, it should be watched to see that it has not bleached sufficiently to become dangerous. The safest plan, perhaps, is to glaze the window with stained red glass, and then to have a curtain over it of an orange colour. It must, however, be remembered that strong orange or red light might affect a gelatine plate, so that if the sun shines on the window during its preparation or



1, Cobalt glass; 2, ruby glass; 3, chysoidine; 4, magenta; 5, flashed orange; 6, stained red glass; 7, bottle-green glass; 8, aurine; 9, quinine.

Fig. 21.

its development, fog might result. It is a safe rule to follow that the light in the dark-room, when the sun shines on the window, should not be greater than the light used when the illumination is only due to the sky alone. An exposed plate should, in any case, be carefully excluded from as much light as possible till development has absolutely commenced, with some plates to prevent a destruction of the image by reversal, and in others to prevent fog. Ruby glass alone is not a sufficient protection, since blue light is apt to permeate it. For comfort, the more light of the proper quality admitted, the better the work that will be done. The value of the light coming through stained orange and ruby glasses is shown in fig. 22. The figure is given, as it is useful to show the extent of the light penetrating through the two media, and this should be compared with the curves in Chapter XIV. If the illuminating

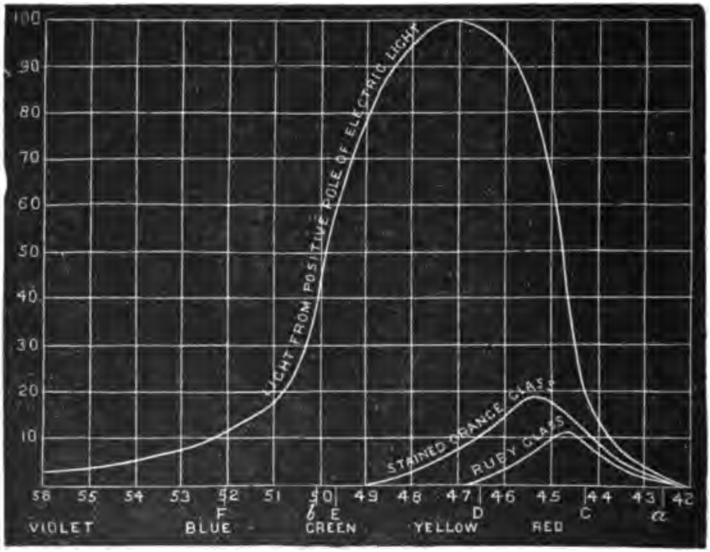


Fig. 22.—The heights of the curves at any point show the relative luminosities of the colours.

value of the electric light, which is very like sunlight, be taken as 2600, then the light transmitted by orange glass is 270, and that transmitted by ruby glass 115. In other words, orange glass cuts off $\frac{9}{10}$ of light, and ruby glass cuts off $\frac{22}{23}$ of light.

There are many advocates for what is known as canary medium, which is paper impregnated with lead chromate. In situations where direct sun does not beat against the window, two thicknesses of this material may be used for developing purposes; but for preparing plates where the room is illuminated by daylight, we do not recommend it. There is a common orange paper which cuts off more of the green light than the canary medium, and allows more orange and red to pass. Two thicknesses of this placed over a window facing north may be used almost with impunity for developing purposes.

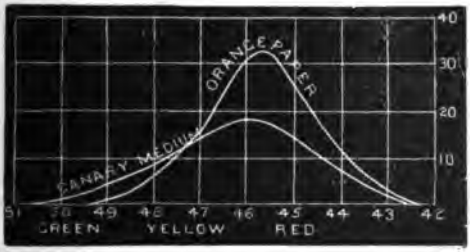


Fig. 23.

Fig. 23 shows the colours in the spectrum transmitted through the canary medium and orange paper. The height of the curves shows the amount of light transmitted at different points. The total illuminating value of the two is nearly as one to two in favour of the orange paper. There is one point, however, in favour of the canary medium which it may be worth while mentioning, and which was investigated by the writer.* It is that an object is illuminated better by a very dull light approaching to green, than by one illuminated by red. If a red light and green light of equal luminosity be gradually and equally reduced, the perception of green light

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* *Proceedings Royal Society*, 1891.

will be seen when the luminosity of the red has entirely disappeared. In fact, a green light can be reduced 700 times more than the red before its illumination disappears. Hence, in a room illuminated with faint green light, the dark parts of the room will appear brighter than if the illumination to near objects be red light. Yellow lies intermediate between the two, hence the canary medium has this advantage over the red and also over the orange, but in a less degree.

Artificial Light.—For coating plates with gelatine emulsion, we advise that artificial light be used, as it is safer in many ways. The principal reason is, perhaps, that artificial light contains so much less blue and green rays than does sunlight or the electric light, and in case any small percentage filters through the screen, it will be far less with the former than with the latter. The annexed diagram, fig. 24, shows the rapid diminution in green and blue rays in artificial light, and the preponderant amount of them in skylight as compared with sunlight.

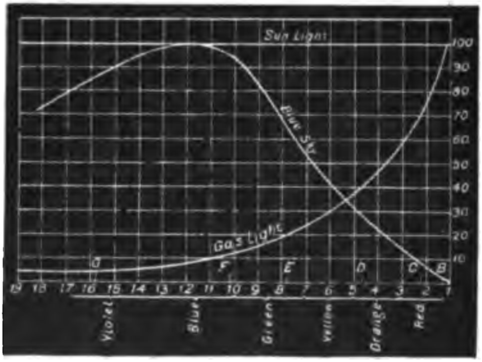

Fig. 24.

If artificial light be required, the best plan is to have a gas-flame or lamp outside the window; but this is only sometimes possible. In case it is possible, a little window should be cut in the wall in front of the sink, and glazed as before indicated, through which artificial light may be used.

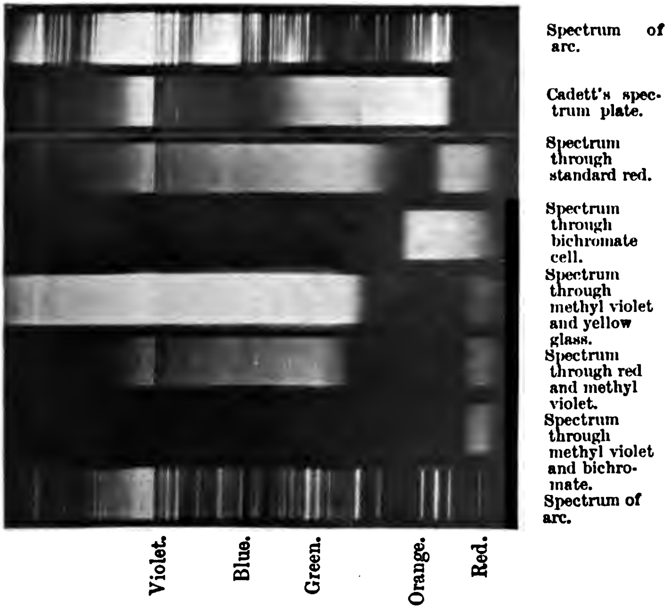

Fig. 25.

To face p. 46.

For ortho-chromatic plates the illumination of the dark-room requires special care. It should only be illuminated by the extreme red rays. This is somewhat difficult to effect. But the writer has found that by a combination of stained orange glass with a gelatine film stained with methyl violet a red light is obtained which answers the purpose. Fig. 21 shows the absorption spectra of various glasses and their combinations.

We prefer, for illuminating a dark-room by artificial light, a translucent medium, such as paper, for the reason that the source of illumination is a surface, and, in consequence, the shadows, which would be deep, with a flame as a source, are better lighted up, and the illumination appears more perfect. Canary medium may be employed in two thicknesses, and is a pleasant light to work by; but we have a preference for the two thicknesses of orange paper, although the light is a little redder. Direct light from a luminous source through proper glass is, however, at times desirable, as, for instance, in examining an undeveloped gelatine plate for dull spots, which then are readily seen by light reflected from the surface, though they will not show by the light issuing through paper.

Fig. 26.

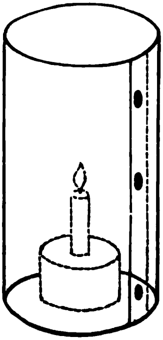

Fig. 27.

Fig. 26 shows a pyramid lamp made in bellows form, which is very useful for travelling; it folds up flat and stands on any table. A carriage candle within gives an excellent light, and the fabric cuts off nearly all hurtful light.

A very portable lantern is shown in fig. 27, and is a contrivance by Mr. G. Selwyn Edwards. It consists of a sheet of stiffish orange or canary-coloured paper folded in a cylinder as shown, and fastened with paper-fasteners. Over the top is placed a piece of the same paper, bent as shown in fig. 28. This gives an all-round light, which is very useful. The paper, of course, may be flattened out again after withdrawing the paper-fasteners, and packed flat in a portmanteau. The paper may also be folded as fig. 29 in section, and will then fold flat. It will make a square lantern, when in use. The top (fig. 28) may be used with it.

If a storage battery be at hand, no better light can be used than a glow-lamp of about ten-candle power covered with orange paper. It is a luxury to work with such a light, as it is as safe as candle-light, and can be completely covered in.

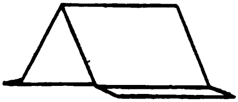

Fig. 28.

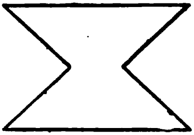

Fig. 29.

There are a great many portable lanterns in the market, which we will not particularise. The photographer is, however, recommended to be satisfied with a simple lantern, which will only transmit light which can be safely used. He should test his lamps by placing an unexposed plate in a slide, the front being half opened two feet away from it, and leave the exposed portion of the plate for a couple of minutes to its action; if the exposed half only slightly veils under development, in the dark the light is sufficiently safe to employ.

Size of the Dark-Room.—As to the size of the dark-room, we strongly recommend that it be as lofty as possible. The generality of dark-rooms are too small for health, and certainly for comfort, a mere cupboard often being substituted for a well-ventilated room of moderate dimensions. A certain amount of cubic space will be doubly necessary if many hours are to be passed in preparing plates and developing.

The figure below shows a plan which will be found convenient. It is a room only 6 feet square, which, we think, is the minimum that should be allowed, if it is the only photographic dark den available for all purposes. A is a working table from 2 feet 9 inches to 3 feet high, and B a small lead sink 2 feet by 1 foot 6 inches in dimension, and 6 inches deep. The sides of the table should have a small inclination of (say) half-an-inch towards the sink, in order that all water may drain into it. The table may also be grooved with the same object, except a small portion on which the developing cups may be allowed to stand temporarily. The water is conveniently admitted by a stand-pipe, from the top of which springs a movable arm with a tap; at the extremity of the arm is suspended an india-rubber tube with a fine rose attached.

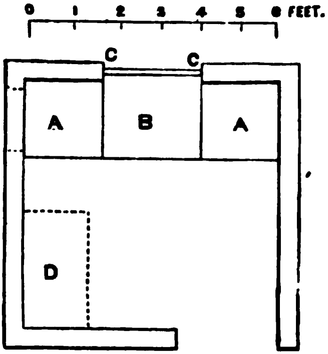

Fig. 30.

This plan enables a plate to be flooded with water without endangering the film, and the arm may be swung back when water is not required. A lid to cover B will give a table on which dishes, during the sensitising of paper and other necessary operations, may be placed. D is a drying-cupboard.

We recommend that the walls and ceiling be papered with varnished paper, as then there is less fear of dust of whitewash settling on the plates. We prefer to have the floor covered with kamptulicon, as it can be easily scoured when requisite.

Fitments.—Shelves there should be in abundance, and also hooks on which to hang brushes, and so on. It is a golden rule in photography to remember "that there is a place for everything, and that everything should be in its place." Funnels, filters, and measures should not be kept in the dark-room, except what may be absolutely necessary, and no slop or spills of developer should be allowed to remain to dry up by evaporation, otherwise spots and all kinds of mischief may be expected to occur in developing either wet or dry plates. The door should be light-tight; a judicious application of india-rubber cording or list will often stop up any cranny through which light might penetrate. A curtain outside the door is often efficacious.

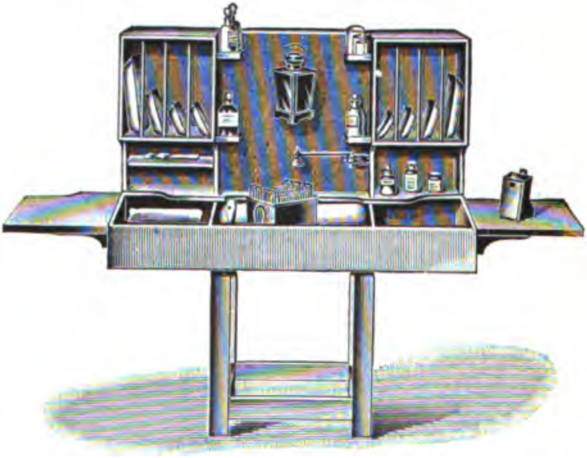

Fig. 31.

Messrs. Beck have a very good arrangement for a developing sink, which is adapted for small dark-rooms. The figure will explain the arrangement.

Baths for Hyposulphite and Alum.—It is handy, in developing gelatine plates, to have dipping baths and dippers for the hyposulphite and for alum. The latter may be made of a piece of oak, with a strip screwed on at right angles to its length. Porcelain-grooved tanks are also convenient, or one such as is shown in the cut.

Fig. 32.

Each plate is held in a celluloid dipper so arranged that adjacent plates do not touch one another. Each trough holds six plates.

Developing Cups.—Glass or white stoneware developing cups are superior to any other, in that they can be kept clean, and the amount of solution in them can be accurately seen, which is not the case with ebonite cups. An ordinary tea-cup is not a bad substitute for a glass measure, as it can be readily seen in a dimly-lighted room.

Draining Racks.—There should be a draining rack in the dark-room to hold negatives after development and fixing. A rack to hold a dozen plates is a useful size to have (fig. 33).

The accompanying figures show a very convenient folding rack, by Tylar, for washing dry plates. Fig. 34 shows it folded for travelling, and fig. 35 shows it opened. As the grooves are protected by india-rubber, a film of gelatine is not injured by insertion of a plate. A rack full of plates may be placed in a tank for washing without handling.

Fig. 33.

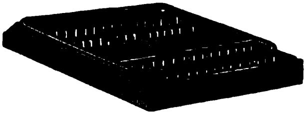

Fig. 34.

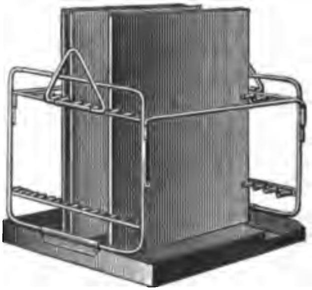

Fig. 35.

Measures.—A four-ounce measure in a developing room is a necessity, as is also a minim measure. The latter should be selected with broad base to stand upon, so as not to be easily overturned.

Developing Dishes.—The usual dishes used for developing are shallow ebonite dishes a little larger than the plates to be developed. These are very cheap, and, if protected from great heat, last well. These are better than the *papier-mâché* dishes, as in alkaline development the alkali is apt to dissolve off the varnish used in them. Celloidin dishes are very excellent, and porcelain dishes for small plates are perhaps better than ebonite, because they are white; but for larger sizes, these latter are not economical, owing to the want of flatness of the bottom usually found with them, and the consequent increase in the amount of developing solution required.

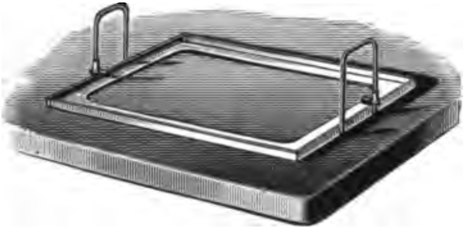

Fig. 36.

Plate Lifters.—Mr. Tylar, to whom the photographic world is indebted for many ingenious contrivances, has brought out what is known as a lifting tray for plates. Fig. 36 will show its design. The frame in which the plate lies is plated with silver, so that the developer does not affect it. The dry plate is placed in the frame, and laid in the developing dish. Two little projections, bound with india-rubber, attached to the handles, which fold back, hold the plate, and it can be lifted out from the dish by the handles and examined without the fingers touching the developing solution. They are made in various sizes.

Dusting Brush.—A dusting brush should be found in the dark-room, and hung in some convenient place.

Dusters.—A duster and a towel should be at hand, the former for wiping up any accidental spill of the developer, etc., the latter for the hands, which should always be washed after handling a plate.

Funnels.—Ribbed glass funnels will be found better than those made with smooth glass, as the air which is displaced can, with the former, find a ready exit. For travelling, enamelled iron funnels are excellent and keep clean.

CHAPTER VIII

APPARATUS

The Dark Tent.—As operating in the field with the wet process is a thing of the past, we need not allude to the contrivances which have been made for this purpose. It is handy in certain circumstances to have the means of changing plates and developing in the day-time, and a little tent we constructed for this purpose is shown in the figure. It consists of a framework of wood, which folds flat against a base-board. It can be made to weigh but three or four pounds, and can readily be packed in the portmanteau or basket used in carrying the camera when on tour. Over this framework slips a cover made of one thickness of Turkey-red calico and one of black, which covers the whole of the framework and goes beneath

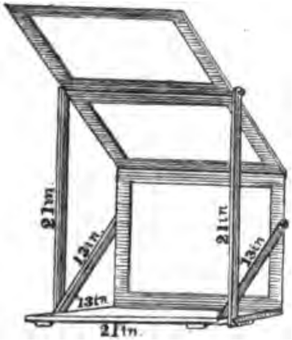

Fig. 37.

the base-board. Attached to it is an apron which is in front of the base-board, and the cover from the top splays out to enable the body to have room, and it reaches down to within a couple of feet of the ground. By tucking up this curtain and the apron round the body all light is excluded. At the back is cut out a window, which is filled with three thicknesses of orange calico, or two of Turkey-red and one of varnished orange paper.

The Camera.—For out-door and landscape photography the camera, to be used on a stand, should be of the lightest possible make, as far as is compatible with rigidity. That form which is known as "the bellows," with parallel sides, when properly made, fulfils the requirements better than any other. In it the lens remains fixed, whilst the ground glass is made to move to attain proper focus. This will be found of great convenience. *Every camera* should have a "swing-back"; that is, the ground glass should be made to hang plumb when required, supposing the camera to be tilted. A circular spirit-level fixed to the top of the frame which swings, and which has been properly adjusted, is useful for securing this. In many modern cameras both the lens and the back can be moved so that one camera is adapted for use with lenses of greatly varying focal lengths. In cameras with a pyramidal bellows it sometimes happens that when using a wide-angle lens of short focus the bellows cuts off part of the picture. Care should be taken as to this. For hot climates and rough usage brass binding to the woodwork is recommended, and Russian leather for the bellows; cockroaches and white ants will then not attack the latter.

For an amateur photographer, a camera to take a 7½ by 5 is recommended as a very suitable size. There are many sizes of plates in the market which are absolutely hideous, the proportion either being too long in proportion to the breadth, or else too much approaching a square shape. We may instance for the former 7¼ by 4½, and of the latter 12 by 10. The water-colour artist employs a very excellent series of sizes of paper, each following one double the area of the preceding one. The sizes are:—7 by 5, 10 by 14, 14 by 20, 20 by 28, 28 by 40. It will be seen that the longest side of each is to the shortest as nearly as possible 7 to 5. It is often said that prints may always be trimmed to satisfy the requirements of good proportion. As a matter of fact, ninety-nine out of every hundred prints are cut to the size of the negative, and hence we insist on the proper shaped plate being used.

A camera should always be capable of taking views in which the greatest length of the plate is vertical. The readiest means of doing this is by what is known as a reversible back. In this the back alone reverses, and not the body of the camera. The camera is of necessity square in this case.

Fig. 38 shows a good form of camera, introduced by Meagher, which the writer has worked with for many years.

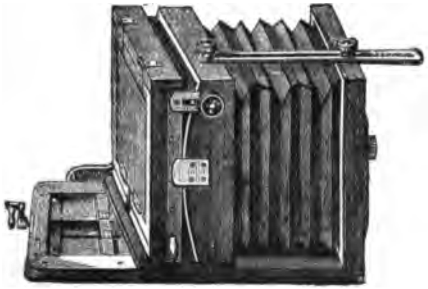

Fig. 38.

It is very light, and, though it has gone through a battle with hot climate and inclement weather, it is still valued as an old and useful friend.

The cut shows the camera when opened for use. Half-a-dozen double backs for dry plates, with the camera, can be well placed in a leather case, and will be quite within the weight for carrying.

It is necessary that such double backs should be carefully made, as the slightest inroad of light into them through any joints is fatal to the rapid plates now extant. The jointed part of the front of the slide should be hinged with leather, or it may be made in the form of roller shutters. Any of the first-class camera-makers will supply slides which are almost feather weights for small sizes, and, at the same time, perfectly light-tight. Instead of double backs, "changing-boxes" are sometimes used.

For our own part, we would never use a changing-box if light double backs were available, as any error in glass cutting often leads to disaster in the changing. Care in selecting the plates before placing them in the box will, of course, avoid this, but we prefer the double backs, as then the right size of plate forces itself on the attention.

Fig. 39 shows a camera by Meagher, which is adapted for copying purposes, occupying the same space, when closed, as fig. 38, but having an extra length, which is pushed forward beyond the ordinary camera front. It has a reversible back.

The cut is taken from an 8½ by 6½ camera, and the length of focus obtainable is 24 inches; whereas, in the ordinary form, without the extra length, it gives about 14 inches focus.

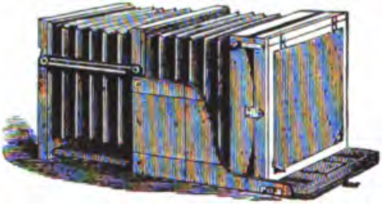

Fig. 39.

There are a variety of cameras in the market which answer fairly well so long as properly handled. Our advice is to get a first-class camera at the outset, and of *as simple a form as possible*. A camera may have endless "movements," and be none the more effective for them. Each extra movement means something extra to get out of order.

It is sometimes convenient to be able to draw the slide from below or from either side. Some reversing backs allow of this. As a type of this and of a good modern camera we may mention Watson's "Acmé" Camera, which is well suited for the tourist's purposes, being at once light, compact, and rigid when on the tripod. It has a pyramidal bellows and reversing back, which can be swung either vertically or horizontally, rising and falling front which can also be swung to bring the lens central to the plate, and can be used with very short focus lens, as the back can be racked close up to the front. It is supplied either with the ordinary screw attachment for use with the tripod top, or with a turn-table for those who prefer that arrangement.

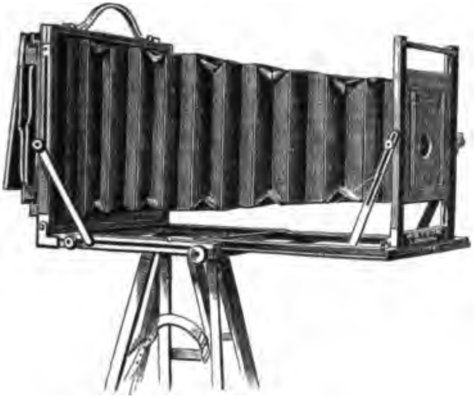

Fig. 40.—Open.

Fig. 41.—Closed.

Fig. 42.

Before taking a camera into use, care should be taken that the inside body has been made *dead* black, otherwise reflections on to the plate may occur, giving a foggy appearance to portions of the negative. The mode of testing this instrument will be patent to all, the chief defect to be looked for being a want of coincidence of the rough surface of the ground glass with the rebates which support the sensitised plate in the dark slide. Perhaps as simple a method as any of testing this coincidence is to place a dry plate in the dark slide, open it back and front, and focus on the film; the slide is then withdrawn, and the focussing screen replaced; if the focus on the latter is correct, the adjustment is complete. Well-seasoned mahogany is the wood most suitable for a camera, and it should be borne in mind that polish gives greater durability to it.

Fig. 43.

Fig. 44.

For portraiture, a heavier camera may be used, as lightness is not essential in this case. The bellows form is not necessary, and a solid camera may be procured. For portraiture, the lenses employed are usually heavier than for landscape work, and this necessitates a greater rigidity.

Ground Glass and its Substitutes.—When the ground glass of the camera has been broken, circumstances sometimes prevent it being replaced by a purchased article. The following method will give a substitute for it.

Take a piece of glass of the size to be ground. Lay it flat on a board or table, sprinkle the finest emery over the surface, and moisten it. With another small piece of glass grind it smoothly and evenly till a uniform grain is apparent over the whole surface. The finer the emery, the finer will be the resulting grain. A substitute for ground glass can be produced by sensitising a wet plate as usual, exposing and developing till there is a fair deposit on the film (if the developer be acidified with nitric acid in lieu of acetic acid, the silver will be deposited in a white form); use the silver as the ground surface of the glass. White wax dissolved in ether, and flowed over the plate, as in mounting transparencies, gives the finest surface possible on which to focus. A thinly-coated gelatino-bromide or chloride plate is also a good substitute, or celloidin which has a matt surface.

Camera Legs.—The camera legs for landscape work should be of such a length as will allow the lens to be raised some five feet or more from the ground. This rather exceeds the average height of the eye. There are various portable folding and sliding legs extant, from which a choice may be made. Rigidity and portability are the first considerations. In choosing legs, they should be erected, when it will soon be seen whether they fulfil the necessary conditions. The top of the stand should be of proper dimensions to hold the camera steadily and without shake. When legs with a triangular brass top are chosen, it will much save the camera, and assist in giving steadiness, if the top be covered with a flat disc of wood attached by wire. The accompanying figures (45 and 46) show a set of legs the main principles of which were brought out by Col. Noverre, but which have been altered to suit climbers and tourists, so as to project but little beyond the shoulders when strapped across the back. Experienced mountaineers have used these in difficult ascents, and they have been admirably and strongly made by Meagher. For portraiture, the camera stand is usually made of a rising pedestal form, the adjustment for height being made by a rack-and-pinion, and a tilting motion in somewhat the same way. In some cases a rotating head is let into the camera itself. This is not always advisable, as some patterns with these heads will not stand on a flat surface, which is often required, but necessitates the employment of a tripod.

Holders for Sensitive Negative Paper, and for Thin Celluloid Films.—For exposing rolls or sheets of sensitive negative paper in the camera, there are various contrivances. With paper, unless tension is given to the sheets, there is a great liability to cockle.

Fig. 45.

Fig. 46.

Holders for single sheets can be made by any one. Cardboard, a wooden board, or ebonite of exactly the same size as the paper, is used as the backing. A mask is made in brass or galvanised iron, and curled over this board; the paper or film is placed on the board, and the two are slided into the mask. Again, a flat zinc mask of the size of the plate, cut out within

¼ inch of the margin, may be placed in the slide, the paper on this, and then it may be backed with a glass plate.

Mr. Warnerke used a board on which linen is glued. The linen is given a coating of a solution of india-rubber rendered tacky by the addition of some gum. The back of the paper or film is pressed against this, with the result that it adheres to the tacky surface, and can be thus used in the ordinary dark slide; a medical plaister (such as are made adhesive) will answer the same purpose. We used, at one time, cardboard covered with a coating of gelatine and glycerine (as made for the various "jelly-graphs"), but found, when paper was used, that it absorbed the glycerine, and the tackiness rapidly deteriorated. A very effective way of exposure is to have the corners of a card the size of a plate ordinarily used in the slide coated with this mixture, and to cause the corners * of the paper to adhere to it. To our mind the simplest plan is the best, and we certainly like the last-named. For Hand Cameras see Chapter XXX.

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* The edges of postage-stamps are effective at a pinch, instead of the glycerine and gelatine at the corners.

CHAPTER IX

LENSES, "STOPS," AND PINHOLES THEORETICALLY CONSIDERED

A SINGLE lens made out of a single piece of glass will have different lengths of focus for different spectrum colours. A lens made of the glass most in use will have the focus for the violet rays shorter than the green, and the green than the yellow, and yellow than the red. By making a lens of two or more kinds of glasses, it may become, approximately, achromatic—that is, the focal lengths of the different rays may coincide. Strictly speaking, if two glasses of different dispersive power are combined, the focal lengths of only two rays can be made equal; and if three glasses, of three different rays. Thus, if white light were merely composed of three rays, then the whole of the light would be brought to the focus. As the rays are infinite in number, it follows that, even with three glasses, the focus of many rays will not accurately coincide with the focus of the three that are made to coincide, although all will be made to lie closer together. In many lenses, particularly of foreign make, either the calculations for achromatism are not correctly made, or else the densities of the glasses vary from time to time, and it will often be found that a lens which is sold as achromatic is really not so, but that the focus of the most photographically active part of the spectrum differs from the visual focus—that is, from that of the brightest part of the spectrum. As a rule, the optician endeavours to make the focus of these two parts of the spectrum agree, and when he fails to do so, a lens, if not useless, is, at all events, not to be recommended. If a lens does not give in a negative the image of (say) black ink lines on a white surface as sharply defined as they are seen on his focussing screen, one of two things is the case: either the lens is non-achromatic, or else the surface of the focussing screen of the camera does not lie in the same plane as that occupied by the plate in the dark slide. The first point to settle is as to this latter possibility, and it can easily be ascertained by focussing the image sharply on the focussing screen, and then placing a piece of ground glass, or a moderately thin gelatine plate, in the slide, opening the back, and seeing if the image on the latter is as sharp as it was on the former. If not, the camera should be returned to the maker, with a demand that this defect should be made good. It may be stated that a camera from any first-class maker may be said to be invariably free from such a drawback, and his reputation would inevitably suffer from such carelessness. Suppose the camera to be correct, and the image is still wanting in sharpness, the lens must be at fault. The amount of such difference in focus can be approximately ascertained with a little trouble. A sharp transparency of black lines on transparent glass can be ruled or photographed, and a good focus of their image be made in a bright white light. If a piece of pale cobalt blue glass, and one of signal green glass, be placed behind the transparency, the image can be again focussed, and the distance that the camera screen has to be moved from the first position can be measured. If the lens be what is called over-corrected, it may have to be moved back, whilst if under-corrected, it will have to be moved forward. Suppose it has to be moved $\frac{1}{8}$ inch back, then, in every other case, after focussing a subject in white light, the camera screen must be moved back by this amount. The rule is not quite exact, but it is quite near enough to be practically useful.

The flatness of field of a lens can be fairly tested by, first of all, focussing a distant object on the centre of the focussing screen with the largest stop supplied, and then twisting the camera round till the image occupies a position on the margin of the plate. If the camera requires neither racking in nor out to give a sharp focus, the field may be considered flat. If it be not sharp, then the amount that the focussing screen has to be moved will show what curvature the sharp field takes. It may be that with a big stop, no racking in or out will give sharpness. This will probably be due to the defect in the lens which is called astigmatism. Should a lens not have a sufficiently flat field with the largest stop, others should be inserted till sufficient sharpness of image and flatness of field is secured.

The accompanying diagrams in fig. 47 will show how the small stop secures this end.

In the top diagram, let us suppose that we have a landscape lens with a big stop, *ab*, inserted, and that the rays of light, A A, coming from a distant point through the centre of the lens, have a sharp focus at A′, on the plate PP; whilst the rays,

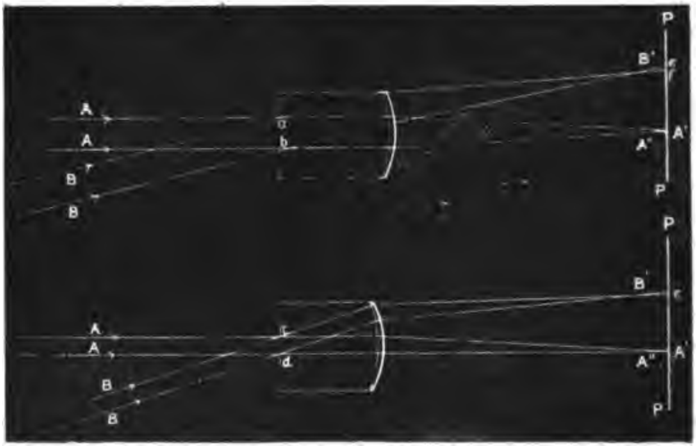

Fig. 47.

B B, from another distant point, which come through the margin of the lens, have a sharp focus at B′. The image of this last point will then spread out to a size *ef* on the plate PP, and be out of focus. If we diminish the aperture, as in the lower diagram, the sharpest focus will still remain at B′, but the "spreading out" will be so small that, practically, *e* and *f* will coalesce, and both images will be in focus on PP. It will also be noted that the plate might be moved between the distances of the focus of B B and A A—that is, from A′ towards the lens as far as B′—without the focus materially suffering.

It may also be remarked that, if the lens have different foci for different rays, the image, when a small stop is used, would be sharp on the focussing screen, and also on the negative. Thus, if, in the lower diagram of fig. 47, the visual focus for the central rays A A was at A′, and for the violet rays at A″, the practical focus for both would lie anywhere between A′ and A″, and hence a badly corrected lens may be employed successfully if a small stop be used.

If a near object and a distant object have to be defined sharply on a plate, the use of a small stop will also effect this. The laws of common optics teach us that the focus for a near object is further from the lens than for a distant object, no matter what corrections are made in the lens. If, then, rays passing through a lens be diminished in section by a small stop, as in the same diagram, and if A″, in this case, be the focus for the distant object and A′ for the near object, manifestly both would practically be in focus on the plate, whilst in the upper diagram if the rays from the distant object met at A″, the point of light to be focussed would be represented by a disc of light approaching to the diameter of *ef* when it reached the plate PP.

By *depth of focus*, in its proper sense, is meant the capacity of rendering objects near and far from the lens in good focus, and we may state that it solely depends on the proportion that the diameter of the stop which is used bears to the focal length of the lens.

Every point of light may be said to be in focus when the disc (commonly called the disc of confusion) made by it on the plate does not exceed the $\frac{1}{100}$ of an inch.

To Find the Equivalent Focal Length of a Lens.—There are numerous ways of finding the equivalent focus to a lens, but some of these have for practical purposes an unnecessary refinement. Three plans will be given, all of which can be very easily carried out. The equivalent focal length of a lens may, without entering into word-splitting, be considered as the focal length for parallel rays, that is, for objects which are theoretically at an infinite distance, though it suffices if they are distant only one hundred times the equivalent focal length. Now, of course, it is easy to obtain the focus of a lens on the focussing screen, but this will not give the point from which such focus is to be reckoned. It may be taken as axiomatic that the equivalent focal length is the distance at which a pinhole would have to be placed from the screen to give an image of the same size. As single lenses give distorted images, and as the distortion is increased as the margins of the lens are approached, it is evident that inaccuracy might ensue if this be not taken into account. Practically, this distortion is negligible when the image occupies only 10° on each side of the centre of the screen. If, now, we focus two distant objects whose angular distance apart is such that they lie within this area, we can mark on the screen the exact positions they will occupy. If the lens be removed, and a card—in the centre of which a hole, made by a good-sized pin, is pierced—be substituted for it, we can move the focussing screen away from or towards the card till a position is found where the two images formed by the pinhole will fall exactly on those positions which they occupied when the images were made by the lens. The distance measured from the centre of the card to the centre of the focussing screen will be the equivalent focal length of the lens, which is usually designated by the symbol *f*.

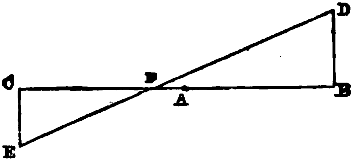

Fig. 48.

Another plan is as follows:—Measure a distance of (say) one hundred and fifty feet away from some fixed point, and place a rod at one extremity. From this point measure a line exactly at right angles to the first, of some 40 feet in length, and place another rod at its other end. Now place the front of the camera exactly over the starting-point of the first line, and level it, the lens being in the direction of the first line. Having marked a central vertical line on the ground glass with a pencil, focus the first rod accurately, so as to fall on the pencil line on the ground glass. Take a picture of the two rods in the ordinary way, and measure back, as accurately as practicable, the distance of the centre of the ground glass from the starting-point, and also the distance apart of the two images of the rods (at their base upon the negative).

Suppose the first-mentioned line, AB, to be 149 feet; BD, the second line, to be 35 feet; AC to be 1 foot; and EC, the distance apart of the two images, to be 2 inches, F being the point where DE cuts CB.

Then BD + CE : CB : : CE : CF, which is the equivalent for focal distance.

$$\text{Here, } CB = 150 \text{ feet } BD + CE = 35\tfrac{1}{6} \text{ feet } CE = \tfrac{1}{6} \text{ feet}$$

$$\therefore CF = \frac{150 \times \frac{1}{6}}{35\frac{1}{6}} = \cdot 711 \text{ feet}$$

This gives the equivalent focal distance, which is the distance of the ground glass from the optical centre. After finding the focal distance by either method, and having taken the thickness of the ground glass previously, the distance may be set off from its smooth side on to the brass-work of the lens by a pair of callipers. This point (the optical centre) having once been obtained, its position should be marked on the brass-work, and from it all measurements should be calculated. This method is *very nearly* mathematically accurate. Were the distance taken of shorter length than those given, an appreciable error might be found. At the distance given, the rays of light entering the lens from the rod are virtually parallel, and thus fulfil the necessary conditions. It must also be remarked that as the distance AB is so great in comparison with AC, any slight error in the back measurement will affect the result by an inappreciable quantity; CE should, however, be measured most accurately from the negative. The mean of a series of trials should be taken.

A third method is stated by Mr. T. R. Dallmeyer as follows:—

. . . "the simplest method I can think of from the practical point of view of the working photographer. It does not necessitate special apparatus, although a true measure and not an approximation, in its theoretical aspect.

"1. *Reverse the lens in its flange* on the camera, and focus accurately upon a distant object (conditions for parallel rays). Measure the distance from some definite point in the mounting of the lens, the hood, for instance, to the plane of the ground glass. (This gives the distance between the hood and the front 'focal plane' of the compound lens.) Say it is 9 inches.

"2. *Screw the lens in the flange in its ordinary position*, and focus accurately upon a distant object (parallel rays). Mark its position upon the base-board of the camera. (The focussing screen now lies in the plane of the back focal point.)

"3. Now proceed to focus accurately upon a near object placed at a distance of three or four times the (roughly estimated) focal length of the lens from the hood of the lens, say 59 inches. The focussing screen will have to be racked out from the position for parallel rays (as in 2) a certain distance. Measure this—say it is 2 inches.

"We know that the distance of the object is 59 inches, less 9 inches (as in 1) from the front focal plane of the compound lens, and that the image is 2 inches from the back focal plane.

$$\text{Hence } F^2 = 50 \times 2 = 100$$
$$\text{or the focal length} = \sqrt{100}$$
$$= 10 \text{ inches."}$$

(*British Journal of Photography*, Feb. 24, 1899.)

Conjugate Foci.—The conjugate foci of a lens are those points where the object and the image are interchangeable; that is, if the object be placed at one, the image will be in a focus at the other. These different pairs of foci are useful to know when an enlargement has to be made. Having obtained the equivalent focal length of the lens, the respective distance of the object and ground glass from the optical centre can be obtained approximately by the following formula:—

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

which is easily reduced to—

$$v = \frac{f(n+1)}{n} \text{ and } u = nv$$

where v is the distance of the focussing screen, u that of object from the optical centre, and f the equivalent focal length of the lens, n being the linear reduction, or enlargement. The above formula is that used for an infinitely thin lens, and is, therefore, not quite exact, but is a close approximation for most lenses.

The following table is calculated with these formulæ:—

For copying, it is useful to know the equivalent focus of a lens as just shown, since by it the distance of a plan, etc., from the lens may be approximately known.

Applying the table to an example:—Suppose the equivalent focal distance of the lens to be 9½″, and that it is desired to find the distance at which the ground glass and the object are to be placed to give an enlargement of four times linear (*i. e.* sixteen times in area). In the first column find 9½, and trace it horizontally till it reaches the column headed 4. Then 47½″ will very nearly be the distance of the screen from the optical centre of the lens; and 11⅞ the distance of the object from the same point.

Effective Aperture of a Stop.—The effective aperture of a stop placed in front of a single lens is given by its area, which is obtained by measuring its radius. Thus, a stop of ½ inch diameter is $(\frac{1}{4})^2 \times \pi$, or $\frac{1}{16} \times 3\frac{1}{7}$ approximately, that is, $\frac{1}{16} \times \frac{22}{7}$, or ·196 square inch. It must, however, vary with the focal length of the lens, since the brightness of the image depends on the cone of light, and is conventionally expressed as $(f/d)^2$, the factor π, being a constant, being omitted, since, in comparing one aperture with another, it vanishes, as will be shown presently. When a stop is placed between the combinations of a doublet lens, the effective aperture is not given by measuring its diameter. Rays of light, directly they pass through the outside lens, converge, and evidently more light will pass through the stop than it would do were it in front of the lens, as it is in a single lens. The proper way to ascertain the effective aperture of a stop in this instance is to focus some distant object, and to place in the position of the ground glass a piece of card with a small hole pierced in the centre. If a candle be brought near the hole, a circle of light will illuminate the front lens. The diameter of this circle of light which illuminates the lens will be a measure from which the effective aperture can be calculated, as above. Every stop should be placed in position, and the diameter of the illuminated circles measured and noted. In this case the aperture should be divided by the distance between the focussing screen and the stop. In both the single and doublet lenses the effective aperture of the stop will be different for parallel rays and for rays which converge from a

TABLE OF ENLARGEMENT OR REDUCTION.

Equivalent Focus of Lens.	Reduction.	Enlargement or Reduction.						Enlargement.	Remarks.
		1	2	3	4	5	6		
6″	*u* *v*	12 12	18 9	24 8	30 7½	36 7⅕	42 7	*v* *u*	*v* = distance of image on ground glass, and *u* = distance of the object from the centre.
6½	*u* *v*	13 13	19½ 9¾	26 8⅔	32½ 8⅛	39 7⅘	45½ $7\frac{7}{12}$	*v* *u*	
7	*u* *v*	14 14	21 10½	28 9⅓	35 8¾	42 8⅖	49 8⅙	*v* *u*	
7½	*u* *v*	15 15	22½ 11¼	30 10	37½ 9⅜	45 9	52½ 8¾	*v* *u*	
8	*u* *v*	16 16	24 12	32 10⅔	40 10	48 9⅗	56 9⅓	*v* *u*	
8½	*u* *v*	17 17	25½ 12¾	34 11⅓	42½ 10⅝	51 10⅕	59½ $9\frac{9}{12}$	*v* *u*	
9	*u* *v*	18 18	27 13½	36 12	45 11¼	54 10⅘	63 10½	*v* *u*	
9½	*u* *v*	19 19	28½ 14¼	38 12⅔	47½ 11⅞	57 11⅖	66½ $11\frac{1}{12}$	*v* *u*	
10	*u* *v*	20 20	30 15	40 13⅓	50 12½	60 12	70 11⅔	*v* *u*	
10½	*u* *v*	21 21	31½ 15¾	42 14	52½ 13⅛	63 12⅗	73½ 12¼	*v* *u*	
11	*u* *v*	22 22	33 16½	44 14⅔	55 13¾	66 13⅕	77 12⅚	*v* *u*	
11½	*u* *v*	23 23	34½ 17¼	46 15⅓	57½ 14⅜	69 13⅘	80½ $13\frac{5}{12}$	*v* *u*	
12	*u* *v*	24 24	36 18	48 16	60 15	72 14⅖	84 14	*v* *u*	

point which is not practically at an infinite distance from the lens.

To Calculate Exposure with Lenses of Different Focal Lengths, and Different Sizes of Diaphragms (Stops).—In fig. 49 let AB be the lens having a focal length (AC or BC); describe a circle with distance AC, and centre C. It is manifest that the parallel rays proceeding from a distant point to form an image of the point at C, only a small part of the theoretical possible rays are collected, viz. those falling on a circle having a diameter AB

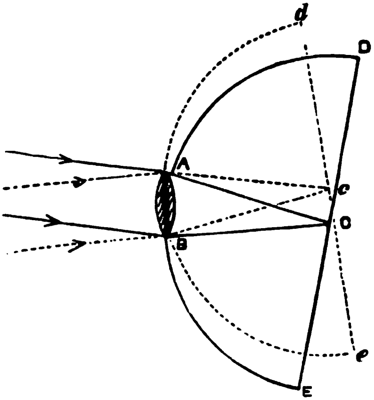

Fig. 49.

(see figure). The theoretically possible rays would be collected on the surface of a hemisphere, DABE. The proportion of rays collected to those theoretically possible is therefore—

$$\frac{\pi(AB)^2}{2\pi(BC)^2} \text{ or } \frac{(AB)^2}{2(BC)^2}$$

which shows that the illumination varies directly as the square of the aperture of the lens, and inversely as the square of the focal length, or as $(f/a)^2$, calling f the focal length, and a the aperture of the lens. If we wish to compare two lenses with different apertures and focal lengths together, all that is requisite is to use the following formula:—

$$\frac{\left(\frac{f_1}{a_1}\right)^2}{\left(\frac{f}{a}\right)^2} \times s = x$$

where x is the exposure required with the second lens, and f_1 and a_1 are the focal length and aperture respectively of the second lens.

As an example, suppose it is known that a lens of 12-inch focal length, and one-quarter of an inch opening, requires an exposure of ten seconds, what exposure must be given to the same picture with a lens of ten-inch focus and one-eighth of an inch aperture? The above formula is—

$$\frac{\left(\frac{10}{\frac{1}{8}}\right)^2}{\left(\frac{12}{\frac{1}{4}}\right)^2} \times 10 = x = 27 \text{ seconds nearly.}$$

It will also be seen that, with the same lens, the exposure necessary to be given varies inversely as the square of the diameter of the stop; thus, suppose with a lens having a stop of half-an-inch diameter an exposure of ten seconds is required, it would require for a stop having a quarter of an inch diameter four times the exposure—or forty seconds. In general, if s be the exposure with a stop of diameter a, with a stop of diameter b the exposure would be—

$$s\,\frac{a^2}{b_2}$$

The above is a rule which has been laid down as correct, but the author has shown that this will not hold when slow plates are employed, and when the apertures vary considerably from one another. When a very slow plate is used, it will often happen that the diminution of aperture D, one-quarter of its diameter, will entail an increase of as much as thirty-two times the exposure, instead of only sixteen times. The reader is referred to the *Action of Light in Photography* * for details.

It also must not be presumed that all glass is equally transparent to the rays which affect a photographer's plate, so that the above rule can only be considered as a rough guide.

Illumination of the Field.—If a lens be directed towards a uniformly white field so that the whole of the focussing screen is filled by the white light, it will be seen, particularly with a wide-angle lens, that the centre of the ground glass is more brilliantly illuminated than the margins.

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* Sampson Low, Marston and Co.

In the case of a doublet lens without any central diaphragm (fig. 50), it is evident that the rays *aa*, *bb*, mark the extreme limits of the field, and that beyond the place where these rays strike the screen there will be darkness. If we have rays *cc*, *dd*, *ee*, coming at a less angle than the axis, XX, of the lens than these rays, only a part of the back lens will be employed, the rays *cc* and *dd* being the extreme limits of the beam that falls on it, the rays *ee* parallel to it falling outside. In the centre of the field alone the full value of both lenses will be utilised; hence, there will be a rapid falling off in illumination from the centre to the margins of the plate. When a stop is made, as in fig. 51, the conditions are changed. In this case the field is much more uniformly illuminated, for the rays covering the greater part of the plate are not cut off by the mount of the back lens. The illumination will not be equal, however, for two if not three reasons. The first is that the stop, if viewed in the direction which *a* and *b* are going, will be elliptical and not circular, as it is when viewed in the direction of *c* and *d*. The illumination of the image formed by the rays coming in the direction of *a* and *b* will be diminished in the proportion that the area of ellipse bears to that of the circle. The second is, that as the plate is not perpendicular to the rays *a* and *b*, the area occupied by the image will be greater. Thirdly, if the rays in the direc-

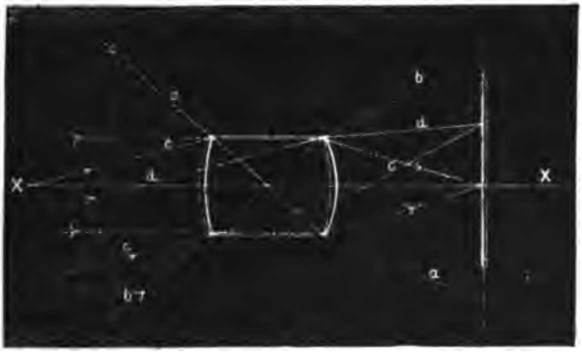

Fig. 50.

tion of *a* and *b* strike the lenses as a whole more obliquely than the rays parallel to the axis of the lens, such as *c* and *d*, more of the former than of the latter would be reflected from the surface, which, again, would diminish the light reaching the plate. The calculation of these several points is intricate, and it is better to measure the illumination of the field directly. This can readily be done by the measuring apparatus described in Chapter XIII., fig. 123. If, in the slide grooves of the camera, a card, in which are the squares A B, be inserted, and if these last be placed at such a height that they are on a line passing through the centre of the focussing screen, they can be moved from the centre to the margin. A strongly-lighted white translucent paper placed immediately in front of the lens will illuminate the whole of the focussing screen with the variable illumination indicated above. The illumination at any point will be sufficient to light up the translucent square A placed in any position. Its value should be measured first at the centre, by moving a candle or lamp to the distance which makes B equally bright with A, the translucent square being shielded by the shadow of a rod. The squares should next be moved to one margin, and again the illumination be measured, as it also can at intermediate points. If the candle in the first case has to be 21 inches away from the screen, and at the margins 25, then the illumination at these places will be as 25^2 to 21^2, that is, as 625 to 441, or as 1 to ·7 nearly. Hence, in adopting a rule for exposure, this falling off in illumination at the margins

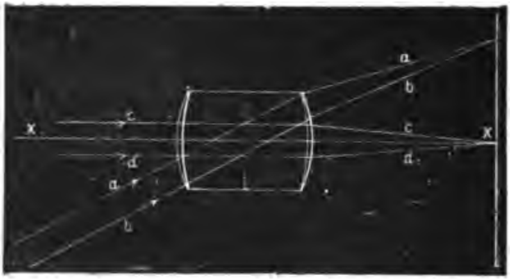

Fig. 51.

should be taken into account. The same falling off of illumination at the margin of the plate is also to be found with single lenses, but in this case the largest fixed stop is usually of such dimensions that all the rays which reach the plate it is supposed to cover, after passing through the stop, fall on the lens, and hence there is no sudden diminution of illumination, which there may be with a doublet lens.

Distortion.—In single lenses, as stated, there is always a certain amount of distortion at the margins of a picture; that is, with a stop in front—as they are almost universally made at the present time—the image of a straight line would be curved, the curve being convex towards the margin of the plate. This curvature is due to the fact that the images of the different parts of the line are formed by different parts of the lens more or less distant from its centre, the size of the stop determining the extent of difference. When two lenses are used—as in a doublet—with the stop symmetrically placed between the two, whilst the one lens—that nearest the picture—will cause a curvature of the line in the direction indicated, the front lens will cause it to curve in the opposite direction, as the stop is behind it. Hence, the one lens by its defect cures the defect of the other, and an image of a straight line at the margins is straight. Mr. Traill Taylor showed that the distortion of a single lens can be cured without altering its focal length by placing a plano-concave and a plano-convex lens of such curvatures that when they are placed together they act as a piece of plain glass in front of the stop of the lens, if the two are slightly separated. By trial the distances can be found where this combination gives a non-distorted

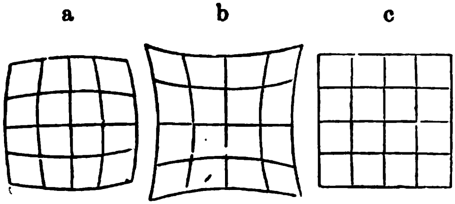

Fig. 52.

image, and evidently the focal length of the photographic lens is not practically altered. It should be mentioned that if a stop be in contact with a lens there is no distortion, but the curvature of the field is great, and a much smaller stop would have to be used to give an approximately flat field than is necessary if the stop be at a certain distance from the lens.

Pinholes as Substitutes for Lenses.—A pinhole may be used as a substitute for a lens, and it is feasible to use such at the present time, when plates are as rapid as they are at the present time. A pinhole will not give a sharp image of a point of light, but will represent it by a series of alternate black and light rings, the number and diameter depending on the distance of the screen or plate from the pinhole, and the diameter of the pinhole. To illustrate the appearance, the accompanying figure enlarged up 24 times from a photograph is given. The pinhole was ·042 inch in diameter, and the point of light ·005 inch in diameter, the point of light being 24 inches from the pinhole.

No. 1 was taken at 3 inches distance of plate to pinhole.
No. 2 ,, ,, ,, 3·5 ,,
No. 3 ,, ,, ,, 4·2 ,,
No. 4 ,, ,, ,, 5·2 ,,
No. 5 ,, ,, ,, 6·8 ,,
No. 6 ,, ,, ,, 9·5 ,,
No. 7 ,, ,, ,, 16·0 ,,

The writer has calculated out the size of pinhole which gives the sharpest image, and he finds that the practice agrees with theory. The diameter should be about $\frac{1}{120}\sqrt{l}$ where l is the distance in inches of the plate from the hole. Thus, if the distance were 9 inches, the best size of hole would be $\frac{\sqrt{9}}{120}$, or $\frac{3}{120}$, that is, $\frac{1}{40}$ of an inch; if the distance were 16 inches, it should be $\frac{4}{120}$, or $\frac{1}{30}$ of an inch, and so on. It must be recollected that a pinhole may be placed at any distance from a plate, and the general sharpness will be nearly the same all over the plate. A pinhole may be pierced in thin brass or zinc. If the metal have any thickness the rim of the hole should be bevelled, so that the light striking it obliquely is not interfered with by the thickness of the metal.

The rule which governs exposure applies to a pinhole. Sup-

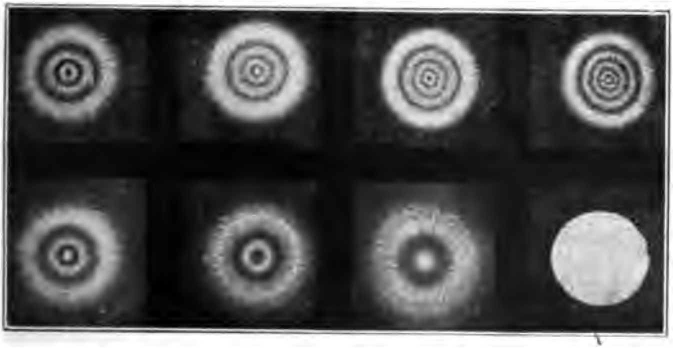

Fig. 53.

To face p. 78.

pose we have a lens of 9 inches focal length, and use a stop *f*/18, that is, half-an-inch diameter, and then for the lens substitute a pinhole $\frac{1}{40}$ of an inch in diameter, the exposures will have to be as 40^2 to 2^2, that is, for the pinhole it will have to be 400 times longer. Thus, if an exposure required with the lens was half a second, the same view with the pinhole would require 200 seconds, or 3 minutes 20 seconds. For further information regarding pinhole photography the reader is referred to the *Action of Light in Photography*.[*]

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[*] Sampson Low, Marston and Co.

CHAPTER X

LENSES AND SHUTTERS

WE have already considered lenses from a theoretical point of view, and it remains to say a few words on the choice of a lens from the practical point of view. For landscape photography where vertical lines are not included in the picture, a single meniscus lens with a diaphragm in front will give the most brilliant image, since there are fewer reflecting surfaces than in a doublet lens. Further, it must be remembered that transparent as glass is, yet it is not totally transparent, and that it becomes a slightly luminous object. The less the thickness of the glass the smaller will this luminosity be. A good single lens should cover a plate sharply with a diaphragm of $f/16$. Probably if an equal attention had been paid to combining together the new Jena glass, as has been done for doublets, a still larger aperture might be effectively employed. A single lens purchased from some well-known maker will be a safe one to use. Personally the writer prefers to use a wide-angle lens, which includes an angle of over 100° on a smaller plate than that for which it is intended. This diminishes the angle, but allows a large stop to be employed.

A Dallmeyer's wide-angle landscape lens is an example of such a lens. It is difficult to lay down any rule as to the angle which a lens should include on a plate of a given size. Roughly speaking, if we take the greatest length of the plate as a unit, the total length of the lens should be about 1¼ units, if the most generally useful lens is required. Thus, for a quarter-plate 4¼ × 3¼, a lens which is rather over 5 inches in focal length will give a picture which does not appear distorted by exaggeration in size of objects in the foreground. This applies not only to single lenses, but also to doublets. A doublet lens is an essential for architectural pictures and for portraiture. There are many forms of these, all of which have their merits, if guaranteed by the name of a good maker. But without such guarantee the doublet lenses sold are often worse than useless. Certain cheap lenses which are sold for under £1 are frequently very defective, and no sharp picture can be obtained with them unless a very minute stop is employed. For this reason they should be avoided. The new forms of doublets made with Jena glass allow an aperture of *f*/6·5 to *f*/8 to be used without loss of definition, and it is one of these forms that we recommend to the notice of photographers. For they are not only usable with these large apertures, but also with apertures so small that exposures by hand can be made even with a very rapid plate. The above diagrams give sections of a "Cooke" lens by Taylor, Taylor and Hobson, and a Dallmeyer or Ross doublet can also be recommended. (See figs. 101, 103 and 104.) It will be seen that they differ in section one from the other, but they all are excellent lenses for landscape work. Our advice is to try one of these forms, and use it as directed by the maker.

Fig. 54.

An iris, or expanding diaphragm, is supplied with some of these lenses, and is a really useful adjunct, as it allows a change in aperture to be very rapidly made.

A lens should be looked upon as a very delicate piece of apparatus, and should be carefully guarded against damp and against scratching. Its surface should be kept perfectly clean by the application of soft chamois leather, as if not the lens during exposure may become so self-luminous as to fog a plate in those parts which should show no deposit. Any one who observes what effect a dirty window-pane has on the light sent into a room will know that a lens with dirty surfaces cannot possibly give an intense image.

The following is an historical account of photographic lenses compiled by Mr. R. Child Bayley for the Catalogue of the Royal Photographic Society's Exhibition at the Crystal Palace, 1898, and in an abbreviated form it is given in the following pages. It is thought that this account will be of use to the reader, more particularly as it embraces the lenses of most modern construction.

Note.—In the diagrams of lenses which follow, except those of Messrs. C. A. Steinheil Sohne, an uniform system of indicating the nature of the glass employed by means of the shading has been adopted.

Flint glass is indicated thus :— ▨

Crown glass of low refractive power, thus :— ▧

Crown glass of high refractive power, thus :— ▤

(These two are used indiscriminately in lenses made before the introduction of the new Jena glass.)

Extra light flint glass, thus :— ▥

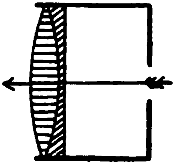

Fig. 55.—Early form of doublet by Chevalier.

A water lens now in the Museum of the Royal Photographic Society is, in its simplest form, composed merely of a clock glass fastened on to a piece of plain glass with a piece of putty. (The specimen was at one time the property of Daguerre, and was probably used as a condenser.)

The first lens specially made in England for portraiture was lent by Messrs. Ross and Co. to the Museum of the Royal Photographic Society. It was constructed in 1841, by Andrew Ross, for Henry Collen, an early licensee of the Talbot-type process. It was of doublet form, the back lens B was employed by itself for landscape work, the front lens being inserted, and the two used together for portraiture. In this latter case the paper upon which the image was received was not flat, but was pressed between two curved plates of glass, to admit of a larger aperture being employed. The lenses are screwed into their mounts, and united not by Canada balsam as is usual, but by a film of castor oil.

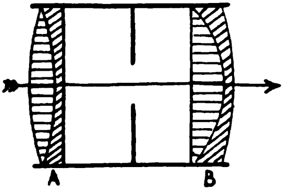

Fig. 56.—The first lens specially made in England for portraiture.

Portrait Lens, by Ross (Ltd.).—A portrait or cabinet lens as now made, practically the same as when introduced by Petzval in 1840.

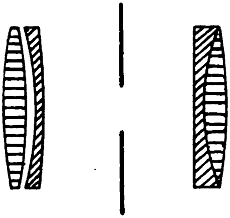

Fig. 57.—Portrait lens.

A Derogy Lens.—A half-plate portrait combination, having bayonet joints instead of the usual screws, and two extra lenses for inserting between the others to lengthen or shorten the focus. The front lens can be used for landscapes, with or without one of the extra lenses, making altogether six different combinations.

Single Landscape Lens.—Manufactured by Andrew Ross; 20 inches focus for 15 × 12 plates. Largest aperture *f*/20.

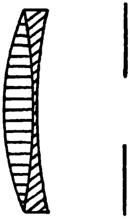

Fig. 58.—Single landscape lens.

This lens is one of a series of seven, the foci of these ranging from 9 to 30 inches.

Archer's Fluid Lens, belonging to Messrs. Ross and Co., is a doublet, each combination consisting of a meniscus shell filled with fluid.

The *Orthographic Lens*, as made by Andrew Ross from the formula of Professor Petzval, about 1859, is shown in the figure. The largest aperture is *f*/14, and it was advertised to take 12 × 10 views, or 8½ × 6½ groups.

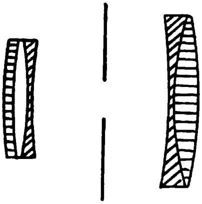

Fig. 59.—Orthographic lens.

The *Stereographic Lens*, as manufactured by Ross (Ltd.), is practically the same lens as the compound stereo lens, which has been made until quite a recent date. It is somewhat similar in form to the Petzval portrait lens, and was adapted for instantaneous work with wet plates. The working aperture is *f*/4.

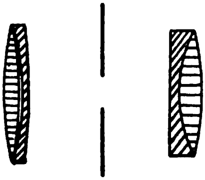

Fig. 60.—Stereographic lens.

Quick-Acting Stereo. Landscape Lens.—Issued in 1860 by J. H. Dallmeyer, in five focal lengths, from 4½ to 8 inches. A cemented single combination, consisting of two glasses, heavy flint and hard crown. An improvement at that date in rapidity (*f*/8, *f*/10) and covering power upon the existing single landscape lenses.

A *Quick-Acting Portrait Lens* was made in 1860 by J. H. Dallmeyer, who constructed it upon the Petzval form of 1840. It was first issued for stereoscopic views of 5 inches focal length. It would work with an aperture *f*/4, and embraced an angle of 45°. Subsequently it was made up to

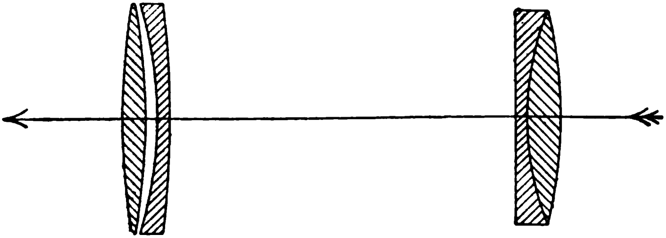

Fig. 61.—Quick-acting portrait lens.

16 inches focus. Its special feature was its fine correction for spherical aberration.

An Extra Quick-Acting Portrait Lens was issued in 1860 or 1861 by J. H. Dallmeyer. It is of the Petzval form, and works with the very large aperture of *f*/2·2. It was issued in three sizes, of 3, 6, and 8 inches focus, and is still largely used on account of its extreme rapidity in modern cinematographic work.

The *Triple Achromatic Lens* was issued by J. H. Dallmeyer in 1861 in two rapidities; the more rapid (*f*/4), termed the "triple group lens," was discarded for the Patent Portrait lens, but the less rapid (*f*/ 10) was issued in focal lengths of from 5 to 50 inches, covering an angle of 69°. It is claimed that this was the *first* non-distorting lens, and gave a flatter field and better correction for astigmatism than any lens made, until the introduction of the new Jena glass. The lens was largely supplanted by the "Rapid Rectilinear," introduced in 1866, on account of the greater rapidity of the latter.

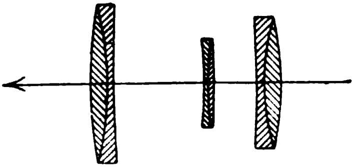

Fig. 62.—Triple Achromatic lens.

Actinic Triplets.—Introduced by Ross in 1861. These were made in ten sizes, covering plates from 6½ × 4¾ to 30 × 24, and the focus ranged from 7 to 34 inches. They were suitable for

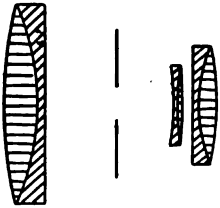

Fig. 63.—Actinic triplets.

all general work, but the working aperture, *f*/ 16, caused them to be superseded by the doublets, which came out a few years later.

Sutton's Panoramic Water Lens.—Invented by Thomas Sutton, 1860, to include an angle of field of 100° and upwards. It is essentially a cylindrical shell of glass of great thickness. The internal cavity being filled with water, the glass shell, having concentric surfaces, acts as a concave lens, the central sphere of water as a convex lens. By employing light flint glass the lens is achromatic when the inner radius of the shell is about one-half the length of the outer radius. The diaphragm is peculiar, being elliptical, with two upright thin radiating portions, like the wings of a butterfly. These stop some of the light of the central pencils, making the beam cylindrical—interfering less with the marginal pencils, which are also almost cylindrical. Even lighting is thus secured, on a curved plate.

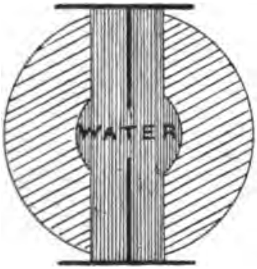

Fig. 64.—Sutton's panoramic lens (1860).

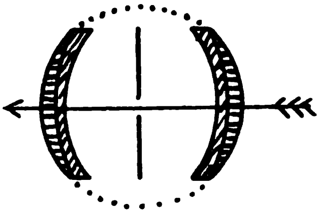

Fig. 65.—The globe lens.

Globe Lens.—In the Museum of the Royal Photographic Society. Stereoscopic pair of globe lenses, by Harrison and Schnitzer, of New York, patented June 27, 1862. Known as the Globe Lens, because the exterior surfaces form part of one sphere. The defects of this form were spherical aberration and flare, but it enjoyed no small amount of popularity when first introduced.

Actinic Doublets were introduced in 1864 by Ross. Their improvement lay in their greater rapidity. They were amongst the first lenses to have both combinations cemented.

(1) The S. A., or Small Angle Doublet, corresponds very nearly with the modern rapid symmetrical lens. The angle embraced was from 40° to 50°, and the working aperture *f*/8. One of 14 in. focus, covered a plate 8½ × 6½ inches.

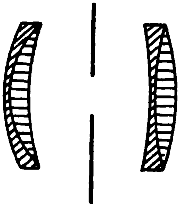

Fig. 66.—Ordinary angle doublet.

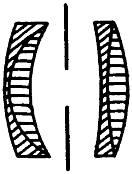

Fig. 67.—Large angle doublet.

(2) In the O. A., or Ordinary Angle Doublet, the angle subtended was from 60° to 75°. This form of doublet was always fitted with a small internal shutter near the wheel diaphragm. The lens works at *f*/16.

(3) The L. A., or Large Angle Doublet, works at *f*/16, and corresponds to the modern wide-angle lenses. The angle included is from 80° to 95°.

The Wide-Angle Landscape Lens was issued in 1865 by J. H. Dallmeyer. It is made in eleven focal lengths of from 5¼ to 36 in. It works at *f*/15, it is free from spherical aberration, with an angle of 75°. It is a single lens of three cemented components. Its chief features are, the wide angle, included for purely landscape work, and the fine and brilliant definition generally, and at the margins. The slight marginal distortion is not noticeable in the class of work for which it was constructed.

The Periscopic Lens, introduced in 1865 by Steinheil, is of symmetrical construction, consisting of two simple crown glass lenses, *f*/13·5. The original (1865) mounting is that shown in the figure.

The Goddard Landscape Lens, in the Museum of the Royal Photographic Society, was introduced by Goddard in 1865. It is provided with three stops, *f*/22, and *f*/27, and *f*/40 approximately.

Patent Portrait Lens.—Issued in 1866, by Dallmeyer, is made in three rapidities, *f*/3, *f*/4, and *f*/6, and includes angles of 50° to 56°. It is issued in sizes from 5 to 37 in. focus. The lens covers a greater angle than the Petzval form, but is so constructed that a certain degree of spherical aberration may be introduced at will, to produce softness in the image when required.

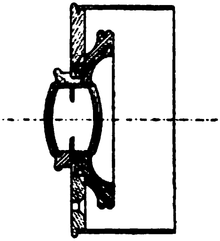

Fig. 68.—Periscope.

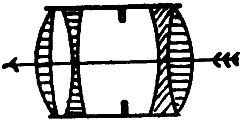

Fig. 69.—Goddard landscape lens.

The Rapid Rectilinear Lens was issued in 1866, by Dallmeyer. The lens, which has an aperture of *f*/8, is issued in fourteen focal lengths of from 4 to 48 in. It replaced the "Triple Achromatic" as a non-distorting lens, free from spherical aberration at a larger aperture. Is composed of two symmetrical lenses, either of which may be used as a long-focus landscape lens. A new optical glass, an extra light flint, was specially made by Messrs. Chance Brothers, of Birmingham, at the inventor's instigation, in order to attain the most perfect results.

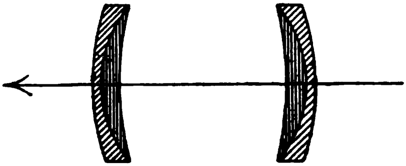

Fig. 70.—Rapid rectilinear lens.

The Wide-Angle Rectilinear Lens was issued in 1866, by Dallmeyer, and is made in eleven focal lengths of from 2 to 18 in. It has an aperture of *f*/15, and covers an extreme angle of 100°.

Aplanat, by Steinheil, Series III., *f*/7, is of symmetrical construction (1866). It consists of two cemented achromatic lenses, of 28 cm. focus. The lens has an arrangement for adjustment of the distance between the combinations.

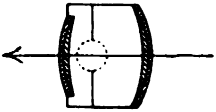

Fig. 71.—Wide-angle rectilinear lens.

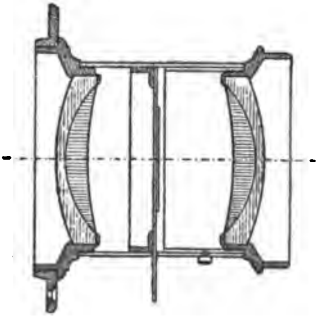

Fig. 72.—Aplanat.

Grub, A. O., Single Lens.—In the Museum of the Royal Photographic Society. The Rapid Symmetrical (*f*/8), the Extra Rapid Symmetrical (*f*/5·6), the Portable Symmetrical (*f*/16), and the Wide-Angle Symmetrical (*f*/16), by Ross, Ltd., were introduced in 1874-5, and superseded the old form of Actinic Doublet, on account of their greater definition, com-

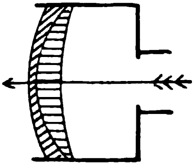

Fig. 73.—Grub, A. O., single lens.

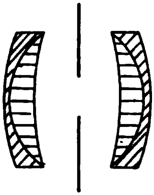

Fig. 74.—Rapid symmetrical (*f*/8).

bined with flatness of field. The form of these lenses is now substantially the same as when introduced, but owing to the introduction of new sorts of glass, their component parts have been slightly modified. There are forty-six varieties of these four forms.

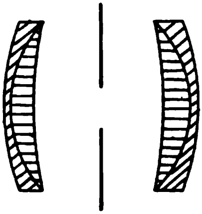

Fig. 75.—Extra rapid symmetrical (*f*/5·6).

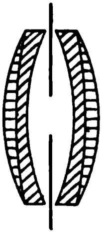

Fig. 76.—Wide-angle symmetrical (*f*/16).

The Rectilinear Portrait Lens, issued in 1878, by Dallmeyer, is made in two sizes of 6 and 8 in. focal length. The aperture is *f*/3. The chief feature is the large intensity of image it gives, for, as both combinations are cemented, there are only four reflecting surfaces.

Group, by Steinheil. Series II. Antiplanat, *f*/6·5 of 1881, has an unsymmetrical construction. It has two cemented lenses, the front lens positive, the back lens negative. The focus is 21 cm., and it has an iris diaphragm.

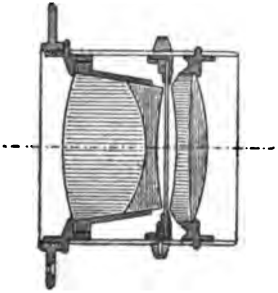

Fig. 77.—Group.

Rapid Landscape Lens.—Issued in 1884 by Dallmeyer, has an aperture of *f*/11. It is made in nine sizes, with focal lengths of from 5 to 30 inches, including an angle of 60°. By the employment of different glasses a higher intensity is obtained than in the "Wide-Angle Landscape," and the foci of the lenses are comparatively much longer than the latter for the size of plate they are designed for.

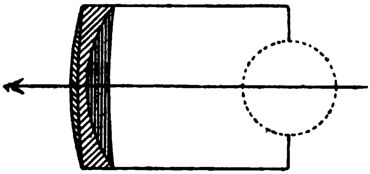

Fig. 78.—Rapid landscape lens.

The Rectilinear Landscape Lens.—Issued in 1888 by Dallmeyer, is made of seven focal lengths, varying from 8½ to 32 in. It has a working aperture of *f*/14, and includes an angle of 60°. It is a combination, mounted in a single cell, with the diaphragm in front, yet is free from distortion.

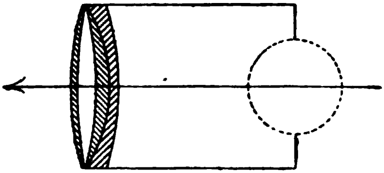

Fig. 79.—Rectilinear landscape lens.

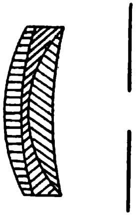

Fig. 80.—Wide-angle single lens.

The Wide-Angle Single Lens.—Introduced in 1890 by Ross. This lens is made from the newer varieties of glass, and consists of three single lenses cemented together. The lens includes an angle of 70° and upwards. It has a working aperture of *f*/16.

Zeiss Apochromatic Triplet (*f*/6·3).—This was the first of the new photographic lenses produced by Zeiss, and was patented in 1890. It was made both in the symmetrical and dissymmetrical forms. The correction for spherical aberration was good, the secondary spectrum was very perfectly eliminated, and it worked with large aperture. Its manufacture was soon discontinued, as it was found that, owing to the imperfect correction for oblique pencils, it presented no marked advantages over the ordinary rectilinear type.

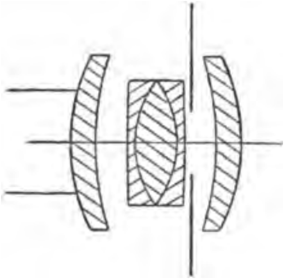

Fig. 81.—Apochromatic triplet (*f*/6·3). Nat. size 100 mm. (4″) focus.

Zeiss Anastigmatic Lens, Series III., is a wide-angle doublet, consisting of four lenses, and was issued in 1890, in nine focal lengths, from 96 mm. (3¾ in.) to 586 mm. (23 in.).

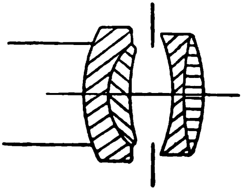

Fig. 82.—Anastigmat. Series III. (*f*/7·2). Nat. size 100 mm. (4″) focus.

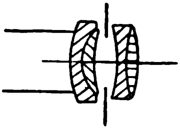

Fig. 83.—Anastigmat. Series IV. (*f*/12·5). Nat. size 100 mm. (4″) focus.

Zeiss Anastigmatic Lens, Series IV., was issued in 1890, in ten focal lengths, from 62 mm. (2½ in.) to 1228 mm.

(48½ in.). This is a rapid wide-angle lens, but has been to a great extent replaced by Series IIIa.

Ross-Zeiss Anastigmatic Lens, Series V., by Ross, Ltd., was issued in 1890, in fifteen focal lengths, from 40 mm. (1½ in.) to 1660 mm. (65½ in.). It is a wide-angle lens, the smaller sizes embracing an angle of 110°. It is well suited for process work, etc.

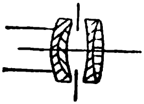

Fig. 84.—Anastigmat. Series V. (*f*/18). Nat. size 100 mm. (4″) focus.

Simple Tele-Photographic Lens, was provisionally protected by Dallmeyer in 1891. It consists of a single cemented positive lens, and a cemented negative lens (both corrected for chemical rays), with variable separation, giving a wide range of equivalent focal lengths, but short back foci. It was discarded for the "Compound Tele-Photographic System."

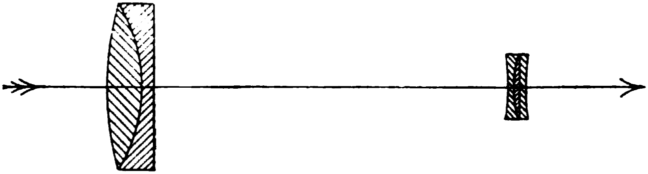

Fig. 85.—Simple tele-photographic lens.

Zeiss Anastigmatic Lens, Series I., was issued in 1891, in nine focal lengths, from 51 mm. (2 in.) to 416 mm. (16⅜ in.), adapted for instantaneous exposures, portraits, etc. Lenses of this series are now made to order only since they have been superseded by the Zeiss-Planar, Series Ia.

Zeiss Anastigmatic Lens, Series II., issued in 1891, in twelve focal lengths, from 54 mm. (2⅛ in.) to 590 mm. (23¼ in.). A very rapid anastigmatic doublet adapted for instantaneous photographs, portraits, etc. Suitably stopped down they are available for use in photography to embrace up to an angle of 85°.

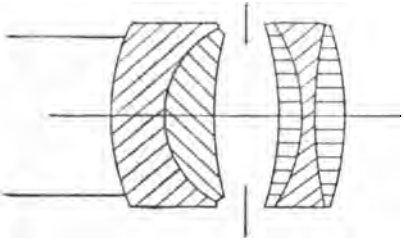

Fig. 86.—Anastigmat. ($f/4{\cdot}5$). Nat. size 100 mm. (4″) focus.

Ross-Zeiss Anastigmatic Lens, Series IIIa., was issued in 1891, in fourteen focal lengths, from 75 mm. (3 in.) to 820 mm. (32½ in.). Being comparatively simple in construction, and consequently cheap, this is a popular lens for instantaneous work, and for wide-angle photography up to 97°. The larger forms are suitable for process work.

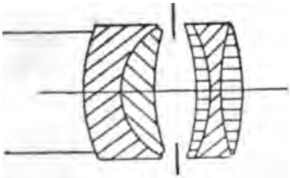

Fig. 87.—Anastigmat. Series II. ($f/6{\cdot}3$). Nat. size 100 mm. (4″) focus.

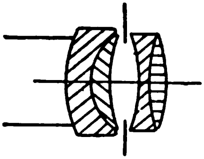

Fig. 88.—Anastigmat. Series IIIa. ($f/9$). Nat. size 100 mm. (4″) focus.

The Concentric Lens.—Patented in 1888, but not issued commercially till 1892, by Ross, Ltd., owing to the difficulty of obtaining the exact quality of glass required. It is composed of two similar or symmetrical achromatic combinations, each being formed of two simple lenses, a plano-convex of glass of high refractive or but low dispersive power, cemented to a plano-concave of a low refractive index, but having the same or a higher dispersive power, these being cemented at their flat surfaces. The characteristic of this lens is its flatness of field when used with a stop of suitable aperture.

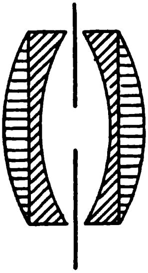

Fig. 89.—Concentric lens.

The Compound Tele-Photographic Lens was issued in 1892 by Dallmeyer. In this system the positive element consists of a complete photographic lens and a negative system that may be used with any such positive system of convenient focal length. The positive system should have an intensity of at least $f/8$. The negative systems are made in twelve sizes, from 1 to 12 in. focus.

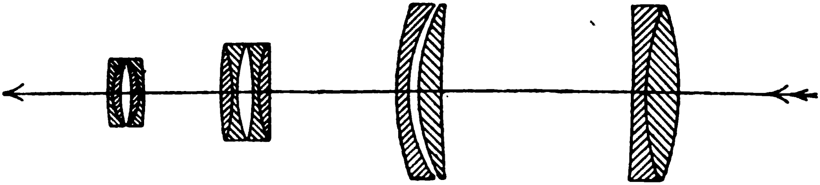

Fig. 90.—Compound tele-photographic lens.

The Ross-Goerz, Series III., was introduced in 1892, in thirteen sizes; 3½ in. to 35 in. Angle included, 70° to 90°.

Rapidity, $f/7 \cdot 7$. A symmetrical doublet, each combination being triple.

Ross-Goerz, Series IV., was introduced in 1892, in seven sizes: 12 in. focus to 47 in. focus. Angle included, 75° to 90°. Rapidity, $f/11$.

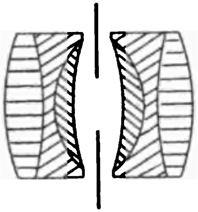

Fig. 91.—Ross-Goerz. Series III.

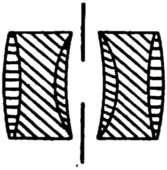

Fig. 92.—Ross-Goerz. Series IV.

Rapid Aplanat, by Steinheil, in 1893, Series II. ($f/6 \cdot 5$), was of unsymmetrical construction. It has five lenses, the front lens double-positive, the back lens triple-negative. It has a focus of 24 cm., and has an iris diaphragm.

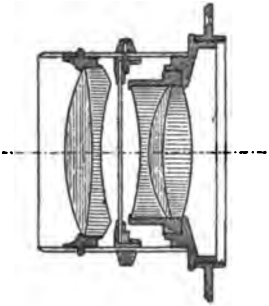

Fig. 93.—Rapid aplanat.

Ross-Zeiss Anastigmatic Lens, Series IIa., was issued in

1893, in nine focal lengths, from 90 mm. (3½ in.) to 433 mm. (17 in.). A rapid anastigmatic doublet.

Zeiss Anastigmatic Lenses, Series VI., were issued in 1893, in nine focal lengths, from 200 mm. (8 in.) to 900 mm. (35½ in.). This was the first of the Zeiss anastigmatic single lenses. They are composed of three glasses of the following description and order :—

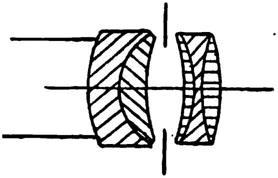

Fig. 94.—Anastigmat. Series IIa. (*f*/8). Nat. size 100 mm. (4″) focus.

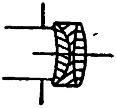

Fig. 95.—Anastigmat. Series VI. (*f*/14·5). Nat. size 100 mm. (4′) focus.

Old Crown.	Flint.	New Crown.
1·510.	1·564.	1·609.

This form of lens yields sharp, flat images, both as regards the central and the oblique pencils. They are, however, like all single lenses, not absolutely free from distortion. Being so well corrected in themselves, they can be combined with one another so that three or four fit in one mount, and thus give a series of single lenses and doublets furnishing a battery with various vocal lengths.

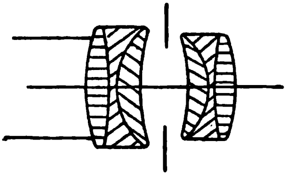

Fig. 96.—Anastigmat. Series VIa. (*f*/7·7). Nat. size 100 mm. (4″) focus.

Zeiss Anastigmatic Aplanatic Lenses, Series VIa., are doublets made up of two similar or dissimilar lenses of Series VI. The nine lenses issued in Series VI. could be combined to yield twenty-four doublets of different foci, from 115 mm. (4½ in.) to 519 mm. (20½ in.). Series VI. and VIa. are, to a great extent, superseded by Series VII. and VIIa.

Zeiss Anastigmat Lenses, Series VII., were issued in 1895, in fourteen focal lengths from 100 mm. (4 in.) to 1000 mm. (39 in.); suited for landscapes, large portraits, etc. This series is an improvement on Series VI. It will be seen that the objective consists of four glasses cemented together.

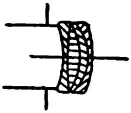

Fig. 97.—Anastigmat. Series VII. (*f*/12·5).
Nat. size 100 mm. (4″) focus.

Ross-Zeiss-Satz Anastigmat Lens, Series VIIa.—This term is applied to combinations of two similar or dissimilar lenses of Series VII. They form doublets of twenty-seven focal lengths from 61 mm. (2⅜ in.) to 595 mm. (23½ in.). They can be used also singly, so that a doublet of the type, having the two single lenses of different focus, forms in all three lenses of different foci.

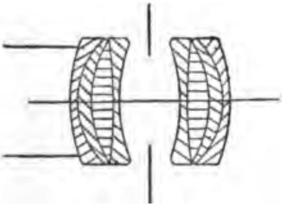

Fig. 98.—Satz-Anastigmat. Series VIIa. (*f*/6·3).
Nat. size 100 mm. (4″) focus.

Stigmatic Portrait Lenses, Series I., by Dallmeyer, were issued in 1896. They are made in four focal lengths of 6 in.

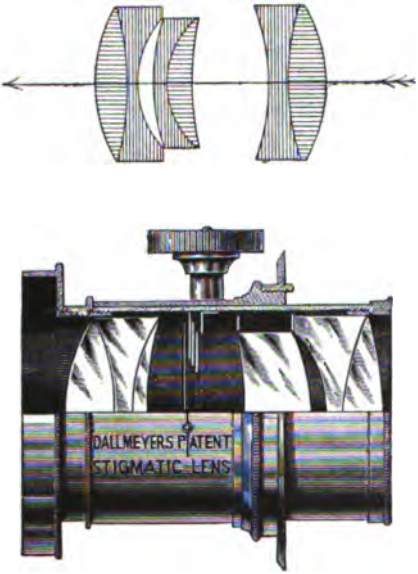

Fig. 99.—Stigmatic (Series I.) portrait lens.

to 12 in. Aperture *f*/4. Angle 60°, free from astigmatism and curvature of field.

Dallmeyer-Bergheim Portrait Lens, by J. H. Dallmeyer, Ltd., was issued in 1896, by Dallmeyer, for J. S. Bergheim, in three sizes. The foci in each size are adjustable; ranging from 20 in. to 55 in. equivalent, in the series. They are constructed on the tele-photographic principle, and give a larger image than ordinary portrait lenses of the same back focus. Designed for portraiture (large heads) only, giving extremely soft definition, by uncorrected spherical and chromatic aberration.

Orthostigmat, by Steinheil, (*f*/6·8), symmetrical construction of 1896. It consists of six lenses, three lenses in each half. It has a focus of 24 cm. and an iris diaphragm.

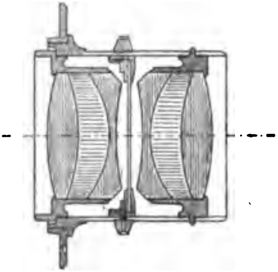

Fig. 100.—Orthostigmat.

Dallmeyer's "Stigmatic (Series II.) *Universal Lens*" was issued in 1897, in eleven sizes, focal length from 3¼ to 18 in. It has an aperture *f*/6, and includes an angle of 85°. There is complete elimination of astigmatism and curvature of field.

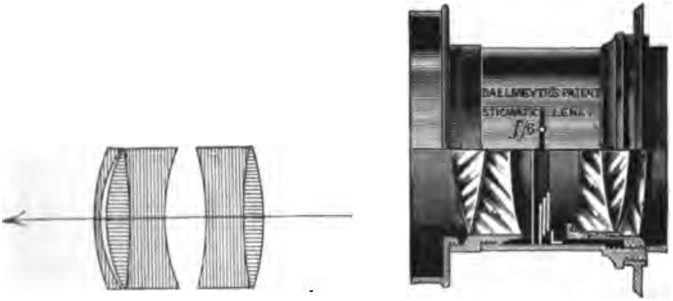

Fig. 101.—Dallmeyer's "Stigmatic (Series II.) universal lens."

The single lenses may be used separately, the front combination having a focus one-half that of the entire lens, while the back has a focus double that of the entire lens, thus giving a choice of three foci.

Ross-Zeiss Planar Lens, Series Ia., was issued in 1897, in nineteen focal lengths, from 20 mm. (⅘ in.) to 840 mm. (33 in.). The characteristic of the Planar is its rapidity, coupled with the absence of spherical aberration, enabling the lenses of long foci to be used with large apertures, but good definition. In its smaller size it forms an intermediate objective between the microscope and the photographic lens, and for photomicrography with a small amount of enlargement it is particularly well suited.

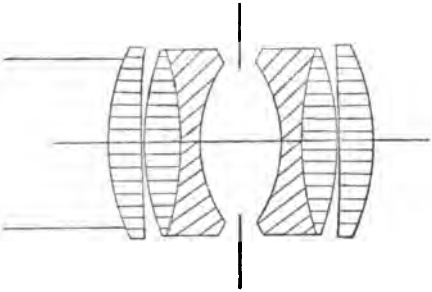

Fig. 102.—Planar. Series Ia. ($f/4$). Nat. size 100 mm. (4″) focus.

Fig. 103.—Dallmeyer's "Stigmatic." Series IIIa.

Dallmeyer's "Stigmatic" (Series IIIa.) was issued in 1899, in one focus only at the time of writing; 5 in. equivalent focus *f*/7·5. Covers ¼-plate at full aperture, or ½-plate at *f*/16. There is complete elimination of astigmatism and curvature of field. The single lenses cannot be used separately. These lenses are issued for hand-camera use as a cheaper form of the "Stigmatic (Series II.) lens." Other foci are to be issued shortly.

Ross Extra Rapid Symmetric Anastigmats.—This series of eleven foci, ranging from 6 in. to 30 in., working with an intensity of *f*/5·6, has been introduced to provide an improved lens, replacing the Universal Symmetrical Series with superior marginal definition. They are spherically and anastigmatically well corrected over the whole field, and cover wide angles with the smaller apertures.

Fig. 104.—Ross extra rapid symmetrical anastigmats.

SHUTTERS.

Shutters.—There are many forms of shutter in the market at the present time. They may be divided into four classes. Those that work (1) in front of the lens, (2) at the back of the lens, (3) between the components of the doublet, (4) close to the plate. If we examine these four positions experimentally by moving a slit across the field, we shall find that the first and second cut off more or less of the field of view as they move across the lens, but opposite parts according as the slit is moved in front or behind the lens. With a shutter close to the diaphragms and between the lenses the whole field is open during the whole time in which any light passes; whilst with the fourth it is manifest that the different parts of the field are successively exposed. The most perfect theoretical place for the shutter is close to the diaphragm, since all the plate must thus receive equal exposure so far as the shutter is concerned. The theoretically perfect shutter is that which opens and closes instantaneously, exposes the whole plate during the whole time, and uses the *full aperture* of the lens uncovered between the opening and closing.

In the first two classes none of these conditions is practically fulfilled; in the fourth, the first condition and the last condition are carried out, and in the third the second is accomplished. The smaller the aperture (stop) of the lens used, the more nearly are all three conditions fulfilled in the first three classes.

We may test a shutter in two ways: first, for the total time during which any light passes; and, second, for the proportion of time during which effective exposure is given to any part of a plate, the proportion being the ratio of the exposure that would be given by a perfect shutter and that which is given. For the first a rough test is sufficient, for except with a shutter between the diaphragms one cannot be certain that quite the whole time of exposure is given, owing to the fact that the exposure of one part of the plate is finished before another. If a man be taught to rotate his arm from the shoulder once in a second, he may hold a small roll of white paper in his hand, and a photograph be taken of him in this act. The angle occupied by the roll of paper on the plate, taking the shoulder as the centre, will give the approximate time during which the shutter was exposing, if the angle, similarly derived, of the roll of paper when stationary, be deducted. In one example we find the angle occupied by the roll in motion was 18°, and when stationary 3°; the angle due to the motion was therefore 15°. As the revolution was once in a second, the time during which the rotation lasted was $\frac{15}{360}$ of a second, or $\frac{1}{24}$ second.

Another simple plan is to attach a small silvered head to the pin of a bicycle front wheel on which there is a cyclometer. The wheel may be caused to rotate (say) three times a second approximately when the machine is upturned. The speed can be judged by the "click" of the cyclometer, the

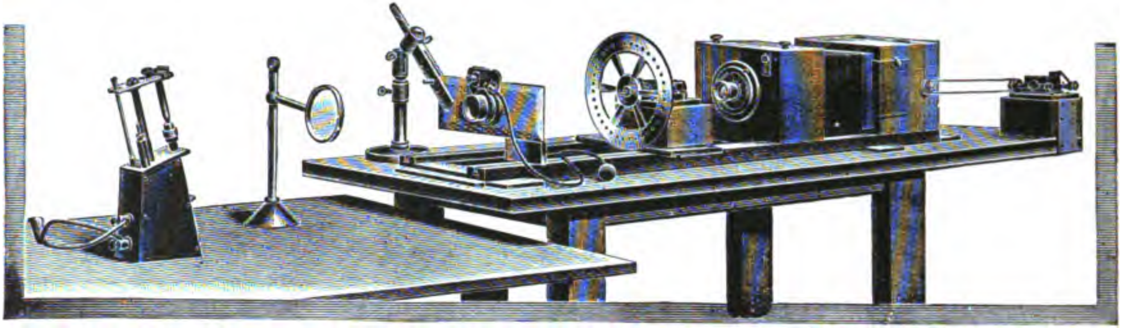

Fig. 105.

number of clicks in any ten seconds being counted. If the sun shines on the bead and an exposure be given in the camera, taking in the revolving wheel, an opaque circular line will give the track of the head. As an example, the bead made a track of 78°, and the wheel was rotating 3·7 times a second. The time of exposure was therefore $\frac{78}{3\cdot7\times360}$, or $\frac{1}{17}$ of a second. With another shutter the wheel revolved five times in a second, and the track made occupied 35° of a circle. The speed was therefore $\frac{35}{5\times360}$, or $\frac{1}{51}$ of a second. There are various artifices of a similar nature which can be employed for the same purpose. The next kind of measures are more accurate, but a special apparatus is required for them.

Fig. 105 shows the apparatus as employed.

Fig. 106.

The principle on which the writer devised this plan may be briefly stated. Suppose we have a slit (fig. 106) through which light passes, we can focus such slit on the ground-glass screen of the camera, and the shutter may be used for the photographic plate in giving an exposure. If the length of the slit be at right angles to the motion of the shutter, part of the image of the slit will remain uncovered, whilst the other part will be covered by the shutter. If the plate were caused to move in a direction parallel to the slit we should get an area showing the slit partially uncovered at one end, gradually find where it was wholly uncovered, and finally the gradual shutting off of the other end. Now, as a bright light is required, it is somewhat awkward to arrange to cast an image of the slit so as to fill the whole width of the lens, and at the same time to be in focus on the plate, so for convenience' sake the shutter is separated from the lens, as shown in fig. 105, and instead of a flat plate moving, as in fig 107, the receiving sensitive surface is a sheet of sensitive gelatino-bromide paper placed round a drum which can be made to revolve at any required speed. Fig. 108 shows this drum.

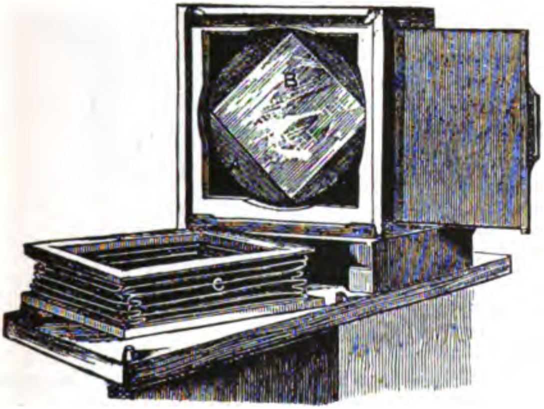

Fig. 107.—From photograph.

In fig. 105 we have, first, the electric light; next, a lens to condense the beam; next, the lens with the shutter to be tested, against which is pressed a horizontal cardboard slit of about $\frac{1}{20}$ in. width. Then beyond is an ordinary camera carrying the drum instead of the ordinary dark slide, the drum being caused to rotate by an electro-motor, which is shown. The speed of the drum is immaterial, provided it is fast enough. Between the camera and the lens to be tested is a wheel as shown, bearing six spokes and perforated with thirty-six holes on the line in equal intervals. This is caused to rotate by another small electro-motor, so that the spokes cross the beam of light. The speed of this wheel when rotating, it is essential to know accurately. This can be ascertained by blowing with a tube against the holes, and recognizing the note given by this syren—by means of a pitch-pipe, when the number of times a hole passes across the stream of air is given. The following scale will suffice—

Fig. 108.

	A hole passes in a second
Middle C	512 times
C sharp	540 ,,
D	576 ,,
D sharp	600 ,,
E	640 ,,
F	683 ,,
F sharp	720 ,,
G	768 ,,
G sharp	800 ,,
A	853 ,,
A sharp	900 ,,
B	960 ,,
C	1040 ,,

When the note is the same as one of these, it gives the number of times divided by six that a spoke passes across the beam.

The image of the slit near the shutter being focussed on the centre of the drum, the shutter is released and we get a diagram of the slit.

A C shows the time it took to uncover the whole of the slit; E B the time during which the whole aperture was uncovered, and F D the time it took in closing. The note in this case was E, or 640 holes passed through the jet of air per second, the number of spokes which passed through the beam was $\frac{640}{6}$ or 107 nearly in a second; the time of opening was 2½ intervals between the passage of the spokes, or ·023 second, of closing—·04 second, and for full aperture ·032 second; the total time being ·095 second, or about $\frac{1}{10}$ of a second. Figures such as these give the efficiency of the shutter. The area of the figure may be taken as equal to 6¼ spoke intervals, allowing for the opening and closing. If the opening and closing had been instantaneous the area would have been 10¼ intervals. The efficiency of the shutter is therefore ·64 of the theoretical shutter. Such diagrams as this are of the same nature as steam indicator diagrams, and give very useful information.

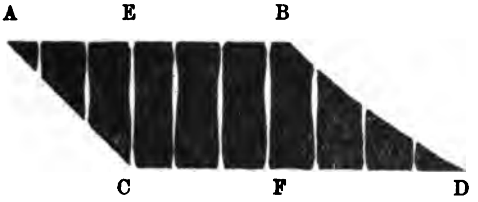

Fig. 109.

In judging of the value of a shutter it follows that account must be taken of the time during which the full aperture is open and the time it takes in closing and opening. Beyond this it is important that the shutter should be as light as possible, so that any alteration in position of the centre of gravity of the camera lens and shutter caused by the motion should be as small as possible. Shutters which open from and close towards the centre of the lens are on this account the best; though of course by means of compensation weights, others may be practically equally good on this score. It may not have been considered seriously by the reader what a small shake may mean. If the plate during exposure has moved but the $\frac{1}{100}$ of an inch, the "disc of confusion" of a point will be increased to an oval $\frac{1}{50}$ of an inch in diameter in the direction of the motion (supposing that such a diaphragm has been inserted in the lens as to give the disc a diameter of but $\frac{1}{100}$ of an inch in diameter), and the image will therefore appear wanting in sharpness.

There is one point to notice in regard to the time taken in opening and closing a shutter, in that the larger the stop employed, the loss of light incurred from the motion is proportionately greater than when a smaller stop is employed. This must evidently be so because the full aperture of the smaller stop is longer open than with the larger. The diminution of stop does not therefore mean a diminution of exposure proportional to the areas, as is the case when "time exposures" are given.

Stops which open and close to the centre have a certain advantage, for they allow a larger stop to be used than is the case where the aperture of the shutter merely passes once the aperture of the lens. As it opens, the shutter acts as a diaphragm, gradually increasing and then diminishing, so that the exposure given is really one through a stop of mean area, between the full aperture and a pinhole. The gain may not be considerable, but it is appreciable where the time during which the full aperture is uncovered is not far different to the time of opening and closing.

We may give a hint as to the kind of shutter to avoid. Shutters with which no variation of exposure can be given will be the least useful. The most satisfactory method of regulation seems to be that based on a pneumatic pressure. Again, shutters in which the moving parts are very heavy will be found awkward in practice, and any shutter which requires a decided push to free it should be tabooed. A pneumatic arrangement for releasing the shutter is usually a safe one to employ, but for some purposes this is an arrangement which is very much in the way. It is best to have a shutter which can be released either by a pressure or by a pneumatic arrangement, according to pleasure.

Where exposures can last at least half a second, Mr. Cadett's flap-shutter which opens and closes behind the lens is an excellent form, and is sufficiently rapid in its action for slowly moving objects. It is actuated by a pneumatic arrangement inside the camera. It is only suitable for cameras working on a stand. It gives a slightly longer exposure to the foreground than to the sky, which is often advantageous.

CHAPTER XI

PREPARATION OF GELATINE EMULSION

The first process which we shall study will be the gelatine process, as its sway in the photographic world is undoubted; and the old wet process, which was the most important one till recent years, will be described later. Plates can be procured in the market at reasonable rates, but those who have leisure will find that they can often manufacture a better plate themselves than they can buy, and that the cost is less, since neither labour has to be paid for, nor profit made. The following details of the manufacture of a gelatine emulsion and of the preparation of the plates have been given for the use of the amateur and scientific photographer. To the latter, particularly, it is often essential that he should prepare his own plates, as the author can testify from ample experience.

Gelatine.—Gelatine is ordinarily hygroscopic, and contains, at ordinary temperatures, from fifteen to twenty per cent. of water. In cold water it swells up, and absorbs from five to ten times its weight of water; good gelatine will absorb enough cold water to dissolve it, if the temperature is raised above 90°. Very weak solutions of gelatine will solidify to a jelly when cold, sometimes when only one per cent. of gelatine is present; but long boiling destroys, to a great extent, this power of setting.

Gelatine will keep indefinitely in a dry state, but in contact with water it soon putrefies, becoming first acid, and then strongly alkaline, and gives off ammonia; at a temperature of 100° decomposition will often begin in twenty-four hours. Hence it is evident that long boiling, besides destroying its power of setting, also tends to produce decomposition of gelatine.

A gelatine which by itself is soluble at a low temperature is unfitted for gelatine emulsions, particularly if the temperature at which it is prepared is at all high, since it would then not set. It is usually alkaline. An example of this is Nelson's No. 1 gelatine. In warm weather it will dissolve in the water at the temperature of the room in which it is soaked. Swiss gelatine or Heinrich's is the other extreme; it will be found not to melt till the vessel has been plunged into water about 110°, and that it is acid. As might be expected, as regards setting, these two kinds of gelatine are the most opposite. At a temperature of about 70°, No. 1 will scarcely set at all, whereas the two latter will set in a short time.

Mr. R. Child Bayley, in a paper read before the Royal Photographic Society, April 14, 1896, described a method of testing gelatine for its melting-point. Having to examine a number of jellies with a view to ascertain the influence of alum and other hardening agents upon them, he devised a piece of apparatus for the purpose. After repeated use he found it reliable and simple. The apparatus consists of a water-bath, of such a section that it can be heated by a spirit-lamp or Bunsen burner, without the hot air or products of combustion reaching its largest side. Along this side at a distance of one inch from the top is ruled a straight line, and one or more thermometers are so supported in the bath that their bulbs are as close as possible to the position of the line on the metal, but inside the bath. To use it the vessel is laid upon its side, and by means of little paper tubes the samples of jelly to be tested are allowed to solidify in discs with the bottom edge of each disc just upon the line on the tank. When the gelatine has set, the papers can be removed and the tank placed upright and filled with water. It only remains to heat the water very gradually when the suspected melting-point is approached. The temperature at which the little disc of jelly commences to slide down the side of the bath is noted.

The best size for the discs will be found to be ½ in. in diameter and ¼ in. thick. With such a size, and keeping the water in the tank still, so that the heating may be gradual, and the currents in the water gentle and free from irregularities, repeated experiments with the same jelly gave well-defined readings, varying not more than ·5° C.

The melting-point of a certain jelly ascertained by the usual means was found to be, in five experiments, 23·0, 24·5, 25·0, 23·0, 24·0, or taking the mean, 24° C. Six discs of the same jelly were placed upon the tank, and all slipped when 26° C.

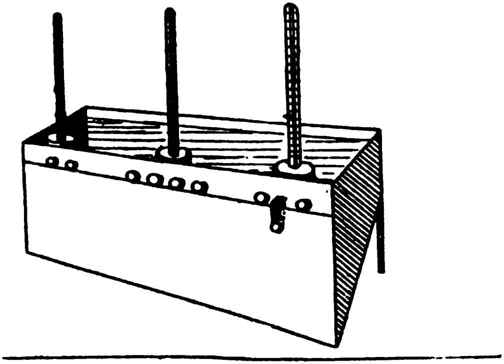

Fig. 110.

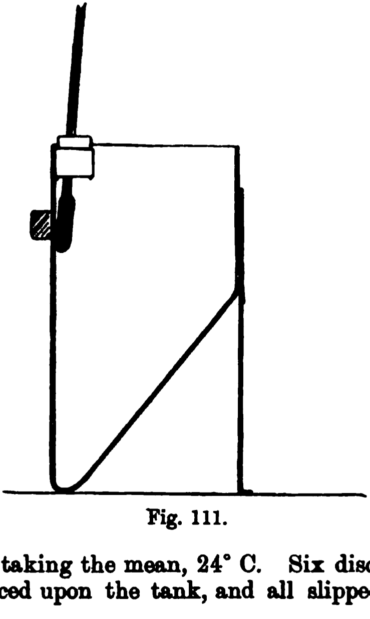

Fig. 111.

was registered on the thermometer nearest them. The experiment was repeated with the same result. The readings by this apparatus are very uniformly two degrees higher than the melting-point as determined by the methods of immersing a thermometer in a jelly and then raising the temperature. The same readings to half a degree are got over and over again by Mr. Bayley's plan. The length of the cylinder of jelly makes no difference in the readings.

An important test is for acidity or alkalinity. For our own part, we strongly recommend a gelatine which is slightly acid where an emulsion is to be boiled, and if not in this state, we acidify the gelatine solution. When the ammonia process (see page 119) is used, the condition of the gelatine in this respect does not matter, except as to what may be expected from its physical qualities. In some gelatines the acidity (due to the hydrochloric acid used in its manufacture) can be tested by applying a piece to the tongue. A hard gelatine can be at once identified, when it is set, after dissolving in water, by the amount of water which it has absorbed.

To select suitable gelatine for an emulsion, we recommend that a small batch of emulsion be made with the specimens proposed to use, and that a few plates not smaller than 7 by 5 be coated and tested before taking it into use for larger quantities.

In our own practice, we like to use either a gelatine of medium hardness, or else a mixture of two kinds of gelatine—one hard and one soft, and the proportions of these we vary according to the weather. As a rule, we like one part of hard to one or two parts of soft, as it will then set with ease at a moderate temperature, and be hard enough to resist any tendency to frill off the plate during development or fixing; and is at the same time readily permeable by the developing solutions.

One fact must also be recollected, that frequent re-heating of gelatine speedily detracts from its setting powers, and that if too little water be added to it in mixing, the film has a great tendency to become leathery, more particularly if a little chrome alum has been added to it to prevent frilling. A judicious mixture of alcohol to a gelatine solution increases permeability, and should not be neglected. The use of a sufficient quantity of water is, however, the great desideratum, and should be carefully attended to, the quantity, of course, depending on the temperature at which the plates have to be prepared; thus, in winter, more water should be used than in summer. A very horny, glossy film is said to be objectionable in many ways, and a matt surface for the plates should be generally aimed at. The kind of surface depends almost entirely on the gelatine that is used, unless it be modified by additions, such as glycerine, to which we may at once say we object, on account of its affinity for water.

We propose to give a detailed account of two methods of making an emulsion in weather of ordinary temperature, say up to 65° Fahr.,* which may be taken as a pattern on which to form others by other formulæ. Both will be found to be exquisitely sensitive to the blue rays, and very slightly to the orange, which latter quality means that the development and preparation of the plates can be conducted in a room with a fair quantity of orange light. In the formula it will be seen iodide has been given, as we consider it as a sheet-anchor for the production of brilliant negatives, much in the same way that a trace of bromide is in the wet collodion process. Those who choose to omit it can do so by omitting an equal weight of silver nitrate when the potassium salt is used. We prefer the first process ourselves, finding it more sensitive. The light to be used in its preparation may be gathered from Chaps. I. and II. Also see Chapter VII., on the Dark-Room.

By both plans a modification of the silver bromide in regard to its molecular state is effected, and it is this which partially gives such extreme rapidity. One cause of the rapidity undoubtedly is that the gelatine is a physical restrainer to development, and hence a stronger developer can be employed without causing fog than is the case with the same modification of bromide when held in a collodion film.

The reader must remember that tricks cannot be played with the light of the dark-room, such as are admissible when the comparatively slow wet process is used. Thus, he should see that no light of the wrong colour penetrates at any place; he should pay particular attention, for instance, to the chinks under the door and in the sashes of the window-frame. When he has come to the conclusion that no white light is entering

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* For other modifications see *Photography with Emulsions*, by the author: Sampson Low, Marston and Co.

his room, he may think about preparing the emulsion. First of all, he must make a few preparations. The jar or bottle in which the emulsion has to be mixed must be scrupulously clean. There should be no patches of old emulsion left on it. If a glazed jar be used, it should be seen that the glaze is not cracked, since fog may be expected if it be. For dissolving the gelatine, etc., we like to use glass beakers with a lip, since they are handy for pouring. These also must be scrupulously clean and dry. The scales in which the weighing has to take place should be examined for dirt (chemical or otherwise), and a few circular filter papers on which to weigh the materials should be at hand. With a view to the subsequent disposal of the substance, weighing is best effected by placing filter papers of equal weight in each pan of the scale. A saucepan of hot water should be ready for the beakers, etc., in which the different materials have to be dissolved, and care should be taken that it is not too full. It need scarcely be said that all weighing can be done in ordinary light. To commence operations, the following proportions of material, which, in grains measure, will coat a dozen or a few more whole-plates, may be weighed out separately, and placed on clean * paper after weighing :—

1.—Potassium iodide	5 grains	5 *parts*
2.—Potassium bromide	135 „	135 „
3.—Nelson's No. 1 photographic gelatine	30 „	30 „
4.—Silver nitrate	175 „	175 „
5.—Hard gelatine and No. 1 gelatine (equal parts)	140 „	140 „

Nos. 3 and 5 are rapidly covered with water, shaken or stirred in it a few seconds, and the water poured off as quickly as possible. This gets rid of any adherent dust on them. Nos. 1 and 2 are then dissolved in 1 drachm (55 *parts*) and 1½ ounces (660 *parts*) of water respectively. To the solution of bromide (No. 2) 1 minim (1 *part*) of strong hydrochloric acid

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* Any contamination by dirt of any description, and particularly that to be found in a photographer's workroom, is almost sure to spoil the emulsion, or at all events its sensitiveness, and to cause endless evils. Hence *clean* paper should be used, and the chemicals should not be left on the benches or table in contact with the wood.

is added. No. 3 is swelled for ten minutes in 1 ounce (440 *parts*) of water, and then dissolved by heat; No. 4 is dissolved in ½ ounce (220 *parts*) of water, and heated to about 120° Fahr. (49° C.).

In the *dark-room* No. 3 is added to No. 4, and shaken up in a bottle till a perfect mixture is secured. Three-quarters of the solution containing No. 2 is then dropped in, little by little, and shaken up after each addition; and then the solution of No. 1 is added to the remaining quarter of the solution of No. 2. The mixture is then added as before. The emulsion should appear of a ruby colour when a thin film of the liquid emulsion is poured on a plate and examined by gaslight.

Boiling the Emulsion.—A saucepan of sufficient size to hold the bottle* must be procured, and filled with water to a convenient height, and a flame, such as a gas-burner, placed beneath it.† After the water has been brought to boiling-point, the emulsion is kept boiling for forty-five minutes, it being shaken at intervals (say once every ten minutes) for half a minute or so. A thick cloth tied round the hand prevents any scalding. The boiling should take place without the cork being left in the bottle or flask, unless there be a vent for the steam to escape. A cork with a slot cut in it answers this purpose. The emulsion, after boiling, when examined by gaslight, should still appear yellow, but when light from the sky is transmitted, it should be of a violet tint. It saves trouble if the boiling continues till this is the case.

Cooling the Emulsion.—After the proper time of boiling, the saucepan is removed. The gelatine No. 5 should, in the interval, be placed in a pot with 2 ounces (880 *parts*) of cold water, and allowed to swell, and then melted at a temperature of about 100° by immersing the pot or flask in hot water. This is added to the solution in the bottle. *Both the emulsion and also the dissolved gelatine* should be cooled to about 70° to 80° F. (25 C.) by allowing water from the tap to run over the jars before the addition is made.

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* To prevent bumping and breaking the bottle, we place half-a-dozen folds of blotting-paper at the bottom of the saucepan.

† We prefer boiling the emulsion in a glass flask to anything else, but a bottle answers if the temperature is *gradually* raised; a *well-glazed* earthenware bottle will also answer the purpose.

Preparation of an Emulsion with Ammonia.—Instead of boiling, the plan may be adopted of emulsifying in the presence of ammonia, a plan originally due to Dr. Van Monckhoven. The modification introduced by Mr. A. Cowan is that we recommend. The quantities of material may be taken from page 117.

A. No. 1 is dissolved in 1 drachm (55 *parts*) of water. No acid is used.

B. No. 2 in 1½ ounces (660 *parts*) of water. No. 3 is soaked and swollen, and dissolved in the same water in which No. 2 is dissolved.

C. No. 4 is dissolved in 1 ounce (440 *parts*) of cold water, and ammonia (·880), diluted to half its strength, is added drop by drop to it till the oxide of silver first precipitated is dissolved.

D. No. 5 is dissolved in 2 ounces (880 *parts*) of water.

B is allowed to cool down to about 70°, when C is added to it drop by drop, with much stirring or shaking. When all is added, A is next dropped in. To the emulsion may at once be added D, and be washed, when it will form a moderately rapid emulsion; or it may be put aside for eighteen to twenty-four hours, when it will become excessively rapid, and then D may be added to it as in the boiling process (see *ante*). The emulsion takes a grey appearance by transmitted light. It will be seen that this emulsification takes place with cool solutions. The gelatine is less liable to be acted upon by the ammonia by this procedure. In warm weather it is recommended that half of D be added at once to the emulsion, and left for eighteen hours, otherwise the emulsion is apt to become granular.

Setting and Washing the Emulsion.—By both methods, after a good mixture by shaking of the emulsified bromide and the extra gelatine, the froth is left to subside, and the emulsion is poured out into a flat porcelain dish,* and allowed to rest. The time which it will take will vary according to the temperature of the surrounding air, but a couple of hours is generally amply sufficient, and often a very much less time

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* When the emulsion is to be "squeezed," if it is set in a jam-pot it turns out in a more convenient shape. In a dish, however, it sets more rapidly, since a greater surface is exposed to the cool air.

will suffice.* After a proper consistency is obtained (such consistency being that the gelatine should not tear with a moderate pressure of the finger), the emulsion is carefully scraped off the bottom of the dish with a strip of clean glass, and transferred to a piece of mosquito netting—such as is used for mosquito curtains—or to coarse canvas,† such as is used for wool-work (see fig. 112), which has been previously boiled in hot water to get rid of any grease or dirt. The emulsion is then twisted up in this, and, by a gentle pressure, squeezed through the interstices, the ball of emulsion being absolutely below the surface of the water into which it is forced. The water causes the thread of gelatine to remain tolerably separate, and, as it passes through the liquid, most of the soluble salts are at once extracted.

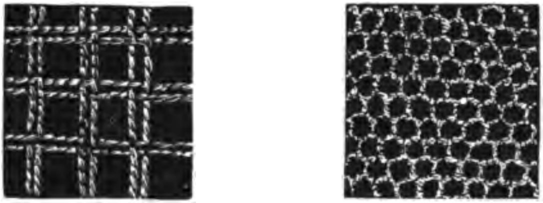

Fig. 112.

When all is squeezed through, the particles of gelatine may again be transferred to the canvas, stretched loosely over the mouth of the jar, the emulsion may be doused with water from the tap or from a water-jug, and then left to soak for half-an-hour. After this the emulsion should again be squeezed through the canvas, and the same operation repeated, thus exposing fresh surfaces of gelatine to the action of water. After another sluicing with water, the emulsion may be considered as washed, though, to make assurance doubly sure, the gelatine may be left at the bottom of the jar, and the water changed two or three times.

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* In very hot weather, if the dish be stood in iced water, no difficulty in setting will be found. It is absolutely necessary that the set emulsion should be firm, as if not it will take up much water in washing.

† The canvas should be as coarse as can be obtained, since, if fine, the emulsion, after washing, has too much water adhering to it.

Dr. Eder, to whose careful researches photographers are much indebted, finds by absolute analysis that emulsions passed through fine canvas are sufficiently washed in about thirty-five minutes in running water, and nearly in the same time in standing water; through coarse-meshed canvas in one and a quarter hours in running water, and in a longer time in standing water.

Draining the Emulsion.—When the emulsion is considered to be properly washed, it is drained. This the writer generally does over the canvas, though some recommend a hair-sieve, but it does not appear that there is much advantage to be derived from its use. The great point in either case is to drain long enough. A couple of hours is sufficient time, and then the emulsion is ready for melting.

It should be noted that before re-dissolving it the emulsion should be firm, and free from all sloppiness (if such an expression may be used), and it will sometimes happen that no amount of draining over a hair-sieve or canvas will render the emulsion sufficiently free from water to set well when dissolved up. We have found that by pouring a couple of ounces of alcohol on a 10-oz. batch of emulsion before draining, the excess of water is taken up, and it becomes fairly firm. One dose of alcohol should effect this, and if not one, two will. The alcohol may be saved if required. In case this artifice be resorted to, none of the alcohol given below should be added to the emulsion when it is re-dissolved. Emulsion that is cut up into shreds is much more easily drained than that which is squeezed through canvas. It is not that the gelatine takes up more water, but that the water clings mechanically to the small particles.

Dissolving the Emulsion.—After draining, the emulsion should be transferred to a clean jar or jam-pot, and then placed in boiling water till all the gelatine is thoroughly dissolved. A temperature of 120° or more may be given it with advantage. The emulsion, when all additions are made, will be about 10 ounces (4400 *parts*).

Separating the Silver Salt.—There is an alternative method of making the finished emulsion, viz. by separating the solid silver salts from the liquid gelatine by means of a cream separator, *before the gelatine No.* 5 *in the formula is added.* A very excellent separator can be procured from the Kodak Company at a moderate price. The following figure shows the machine as used by the writer. A is a movable vessel silvered inside and out to prevent any possible action which might arise, were it of any other metal. In this, after it has been warmed with hot water, gelatine emulsion, which may be four times or even more than the amount given in English measure, is poured in, and the top screwed on (of course in the dark-room), and placed on a spindle S, shown in the figure.

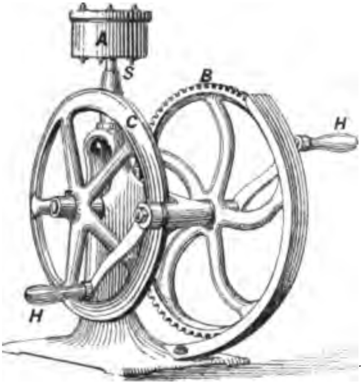

Fig. 113.

The handles HH are then turned so as to make about a complete revolution per second. The toothed wheel B multiplies the motion of C, and C, in its turn, that of S. Each such revolution makes the spindle S, and consequently the vessel on it, revolve about 60 times. The number of revolutions required to separate the emulsion is about 4000 per minute, continued for from five to ten minutes. When the separation is complete, part of the gelatine No. 5, after soaking, is twisted round a glass rod, and with it the solid silver salts which are collected round the sides of the vessel are mopped out after the liquid has been poured away. It may be well to remark that this liquid may not always be perfectly clear; a very small remnant of the silver salt left in suspension will render it quite turbid, but a little experience will show when the separation is sufficiently complete. When the solid matter is mopped out into a jam-pot, the remainder of No. 5 is added to it after dissolving, and the mop itself is heated in the liquid till it dissolves.

Final Additions to the Emulsion.—The addition of half a grain (½ *part*) of chrome alum is sometimes to be recommended. This should be dissolved in 1 drachm (55 *parts*) of water, and added with stirring; 4 drachms (220 *parts*) of absolute alcohol are next to be added in the same way. Chrome alum undoubtedly lessens the speed of a plate to some extent, and formaline may be used in its place for the same purpose. In this case 68 minims of formaline should be added as above described, half a grain of tannin may also be substituted for the chrome alum with good results; but if an iron developer be used, the film will take an inky character. If extreme rapidity* be required, the following procedure may be adopted:—To every ounce (440 *parts*) of emulsion add one drop (1 *part*) of strong ammonia (·880), after diluting with ten times its bulk of water. Keep the emulsion liquid, and at a temperature of 90° F., for a couple of hours, and then allow it to set. In twelve hours it is ready for filtering.

Filtering the Emulsion.—This operation may be carried out in various ways. The writer now uses three folds of swansdown calico which has previously been well boiled and washed. This is allowed to rest loosely in a funnel, and the emulsion filters slowly through it, all coarse particles being left behind.† Wet chamois leather is also often used instead of the swansdown calico. A small plug of washed wool placed in the neck of the funnel is employed by many, and answers well. It is preferable to filter into a flask, as it will bear heat, though an ordinary medicine-bottle will answer if the flask be not at hand. The bottle or flask is again placed in water at a temperature of 120°, and the next operation is to coat the plates.

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* In this case, chrome alum should not be added to the emulsion, as the ammonia causes a precipitate, to which spots on development can often be traced.

† There are several mechanical aids to filtering, which can be procured from dealers.

CHAPTER XII

PREPARATION OF THE PLATES

Cleaning the Plates.—To clean the plates, it is our own practice to immerse them in nitric acid and water (1 to 10), then to wash, and next to rub them over with 10 per cent. solution of caustic potash or soda* and a little methylated spirit. After a wash under the tap the water should flow quite evenly from off them, when, after a rinse with distilled water, they may be set up to dry, which they will do very rapidly if allowed to stand on clean blotting-paper. Polishing a plate is a mistake; it only encourages the formation of blisters, as it prevents the adhesion of a film to the glass. Avoid French chalk, or anything but pure water, and then one of the causes of frilling and blistering will have been eradicated. The plates having been cleaned as above, they are brought into the dark-room, which should, if possible, be kept at a temperature between 50° and 65°, as this is the heat which is most convenient at which to coat the plates and to ensure setting.

If there appears to be any possibility of frilling, a substratum should be applied to the surface of the plate to be coated. There are many substrata that have been used, but that with which the writer has succeeded best is as follows:—

Soak 60 grains (60 *parts*) of Nelson's photographic gelatine in water, drain, and pour on enough boiling water to make 8 fluid ounces (3520 *parts*). Now add 2 drachms (110 *parts*) of a two per cent. solution of chrome alum, and stir vigorously for a minute or two. Filter the solution through paper into a clean measure, keeping it warm and avoiding air-bubbles.

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* A bit of the alkali the size of a walnut, and half-an-ounce of methylated spirit, is sufficient for 4½ ounces of water.

To save trouble, a large quantity of each of the solutions—the gelatine and the chrome alum—may be prepared, and will keep for a long time if a little pure carbolic acid be added to each. No more must be mixed than is required for the batch of plates, as when the compound solution has once become cold, it cannot be again liquefied with heat. The measure and filter used must be well washed with warm water as soon as done with, for the same reason.

The silicate substratum sometimes recommended for collodion dry-plate processes succeeds very well, but it has the drawback that a plate once prepared with it is rendered slightly opaque. This means that the glass cannot be advantageously used again.

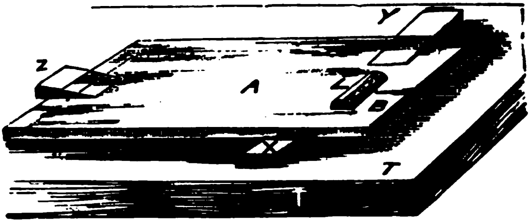

Fig. 114.

Levelling Shelf.—When coated, the plates have to be perfectly level, in order to set. If the drying cupboard has the arrangement of level shelves shown at page 130, nothing further is needed; but if not, a specially levelled slab must be prepared.

In our own practice we have a piece of thick plate glass about 3 feet long by 2 feet broad, and ¾ inch thick; but a slab of slate as long, broad, and as thick as required may be readily obtained and ground true. Slate is very much cheaper than glass. The levelling is done by means of three mahogany wedges or levelling screws and an ordinary spirit-level.

The level L is placed first across the plate, and the two wedges X and Y are altered till the bubble of the level is central; the level is then turned lengthways along the plate, and the bubble caused to occupy its proper position by shifting Z, not touching X or Y. This should cause the plate, if true, to be accurately level; but it is as well to repeat the operation.

A couple of supplementary wedges are sometimes useful if the shelf "spring" at all.

There are several arrangements for levelling plates which manufacturers use, but, as our object is to aid those who only make small quantities of emulsion, it is not necessary to describe them, as it would be beyond the requirements of such.

Coating the Plate.—The filtered emulsion is placed in a saucepan of water heated by a tiny gas-jet or spirit-lamp, the light from which is excluded from the room by means of a tin shade blackened inside. Figure 115 will give an idea of a pot adapted for the purpose of coating. It has the shape of a small china teapot, and into the opening usually closed by the lid a conical china vessel, open at each end, is inserted. The bottom of this opening is closed with a thickness of muslin. Emulsion is poured from the beaker into this, and sufficient emulsion poured from the spout on to the plate, which may be supposed to be an 8½ by 6½, taken on a pneumatic holder, or supported on the tips of the fingers in place of it. As the emulsion is taken from the bottom of the pourer no bubbles should appear. In case such a contrivance be not procurable, about two ounces of emulsion are poured into a warmed 4-ounce measure, *taking care that no bubbles are formed* (which can be secured by pouring out the emulsion against the side of the measure), and a pool of gelatine is made at the top of the plate. It is then, by careful pouring, made to fill up the centre of the plate, and flow to the right-hand top corner, next to the left-hand top corner, then to the left-hand bottom corner, and finally, to the right-hand bottom corner, where it can be partially poured back into the measure. The amount used should be noted; about 80 oz. (3520 *parts*) should coat twelve dozen 8½ by 6½ plates—that is, each plate should have

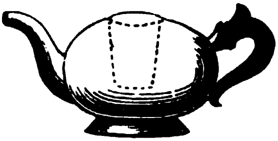

Fig. 115.

about 4½ drachms on it. The plate is then detached from the pneumatic holder (if used), held by the two corners of the diagonal, and very quietly rocked till an even coating is seen to be secured. It is then cautiously slipped on the level shelf, and left to set. Another plate is taken and similarly treated; and when the shelf is full, the emulsion on the first plate will have set, and it must be moved to the drying-rack (page 128), and thence to the cupboard. When the drying cupboard shelves are levelled, the coated plates are at once placed on them. Against one thing we would earnestly warn tyros, viz. not to mix hot emulsion with the cold emulsion already in the pouring-cup, as it is apt to give scum marks. The cooled emulsion should be returned to the flask, allowed to warm up, and then a fresh lot poured out as before into the measure.

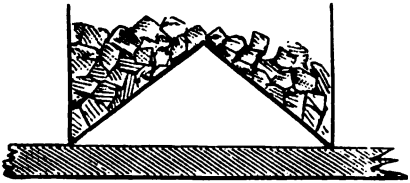

Fig. 116.

There are other modes of coating the plate to which we may refer. After a central pool is formed on the plate as above, the emulsion may be guided by a glass rod along each edge, and thus the chance of spilling is lessened. For our own part, we think that this is not a good plan—first, because the glass rod is liable to collect dust, as it must be wiped between coating each plate; and secondly, if the central pool of emulsion be not spread out rapidly, coating marks are apt to be seen on the finished negative.

Another plan which is advocated is to brush the plate over with a very fine film of emulsion by means of a wide badger-hair brush (kept in a small quantity of warm liquid emulsion), and then to pour over the plate the full quantity. This is not a bad plan if the brush be kept clean. When the emulsion will not flow, our preference is to use a squeegee rather larger than the plate, one side of which is covered with swansdown calico. This should be *slightly* moistened in water (warmed if the weather be cold), and dragged along the surface of the plate, and then the emulsion poured on immediately afterwards. With plates to which any substratum is given, some such artifice is almost necessary, as the emulsion often refuses to flow. In hot weather it is convenient to set plates in a cool chamber. This may be made by a contrivance having a section like Fig. 116, which forms a cool tunnel. It can be made of tin, and should be wider than the plate, and should be long enough to take twelve plates, and be closed at each end, and filled with ice broken into lumps. When placed on the slab, the plates can be pushed along beneath it by each other's aid. A circular top is not so good as the above, since vapour is apt to condense and drop on the plates.

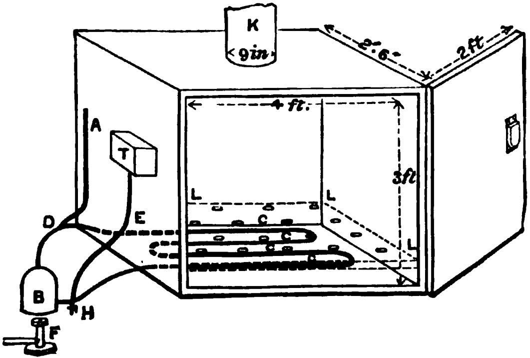

Fig. 117.

Drying the Plates.—For drying the plates, a good drying cupboard is a desideratum, unless an absolutely dark, warm, well-ventilated room, and free from all dust, is available.

The writer has devised a cupboard which answers very satisfactorily, and the plates dry evenly in it.

B is a zinc boiler, from which are taken two pipes, D and H, leading to the coil of pipes, C C C C. A supply tank, T, is fastened against the side of the cupboard, and a supply pipe joins the coil pipe at H. From D another pipe, A, is led, terminated with a tap, which allows any air to be got rid of, which would otherwise stop the flow into C C. At H is a tap, which allows the whole apparatus to be emptied at pleasure. K is a hot-air shaft, being some four feet above the box. It is terminated by a bend in two directions, and can be fitted with a cap, if required, in which are pierced orifices. Beneath are a couple of ventilating inlet pipes, likewise bent in two directions. L L L is a false bottom, pierced with holes, on which the drying racks are placed. F is a gas-jet, which heats the water. (The cupboard is shown with only one door.) Each door is made light-tight by means of fillets, which need not be described. The hinges are pianoforte hinges. The piping is made of composition gas-pipe, though, perhaps, iron would be better; still, as they are, they answer perfectly.

In this cupboard the plates should be so arranged that the warm air may pass rapidly over them.

The temperature of the cupboard should be kept as even as possible, sudden changes being detrimental—producing markings. Opening the drying cupboard door before the plates are dry, when once the heat has been turned on, is a mistake; the plates should be left until it is judged they are quite dry. Very quick drying is also a mistake, as the different layers of the film get an uneven strain, which eventuates in frilling. Twelve hours is about the minimum time which we can recommend unless drying by alcohol is resorted to. The temperature should, if possible, not exceed 80° F., and the gas must be regulated accordingly.

In very hot weather there is sometimes a danger of the gelatine running from the plate in the drying cupboard. To avoid this the hot-water apparatus need not be used, but a small gas-jet placed in K will cause sufficient draught. A small gas-jet will usually be amply sufficient. By this plan the air passing through the box remains at its normal temperature, the air being heated in the tube above. An arrangement must, of course, be made to shield the interior of the box from any light.

A few plates at a time may also be dried in a light-tight cupboard, made as nearly as possible air-tight, in which there is placed a tray containing lumps of calamine chloride, or, better still, asbestos or pumice, which has been soaked in a saturated solution of calcium chloride, and thoroughly dried.

Glass or slate strips, if desired, may be inserted in this cupboard. For plates 8½ by 6½, slips three inches wide are sufficient, and they should be a quarter-inch thick to prevent bending. One end of the slip is supported in a stirrup shown in the figure, in the top of which is a slot, through which a screw is passed into the cupboard; opposite to this is another stirrup, into which are inserted two thumb-screws as shown. This is placed exactly opposite the first stirrup in the cupboard. The strip is placed between these two stirrups, and is first levelled crossways by means of the thumb-screws. When level in this direction, the length of the strip is levelled by raising or lowering the first stirrup, and when in position the screw in the slot is screwed home. When once levelled, the strip will always fall level into position. Gelatine plates are at once placed on these shelves, and allowed to set in the position in which they are to be dried.

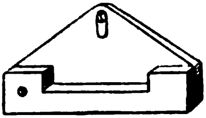
Fig. 118.

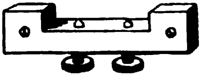
Fig. 119.

It has been stated that markings in gelatine plates may be met with owing to the emulsion setting more rapidly in those parts of the plate which are in contact with the strips. If such should be feared, we recommend threading beads on a string, and tying them round the strips at proper intervals. The setting will then take place without any chance of drying markings, since the plate will be supported by points. This plan is very suitable for warm weather, when gelatine plates take long to set.

Strips of board, in which are thumb-screws, may be substituted for the glass shelves, and these may be levelled.

We have adopted a plan of drying plates in racks which enables more to be dried than in the methods just given in the same cupboard. The racks are made as in fig. 120. They consist of three upright pieces of ½-inch square deals let into two triangular pieces of ¾-inch deal. The former are so arranged that a corner of each faces inwards. In two of them small iron pins are driven, on which the bottom edge of the plates rest. The tops of the plates are supported by the angle

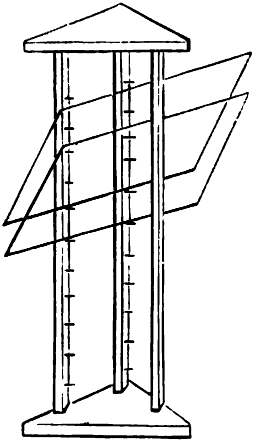

Fig. 120.

of the third deal bar as shown. A cupboard will dry nearly double as many plates on these racks as when they are laid to dry horizontally.

A small thermometer should be hung on the cupboard door, to enable the temperature to be noted.

Drying by Alcohol.—Drying by alcohol is effected by placing each plate, *after thorough setting*, in a dish of methylated spirit free from resinous matter for ten minutes, when it will dry in an hour without difficulty. Modern methylated spirit is not suitable.

Packing Dry Plates.—Plates are best left to thoroughly dry in the drying cupboard or room forty-eight hours, as experience has shown that though surface dry in a much less time, they are not thoroughly desiccated. After this time has elapsed they should be packed in boxes containing dozens if the plates be of sizes 8½ by 6½ and under, or in half-dozens if larger.

To pack dry plates, resort may be had to the plan of separating one from the other by two strips of cardboard or thick paper bent zigzag (as a hem is prepared for stitching), one at each end of the plate. Between each fold are placed two dry plates back to back; the whole bundle should be bound round with twine, and wrapped in non-actinic coloured or opaque paper. The plan usually adopted by makers is to isolate four plates. Two plates are placed back to back, and one fold of a zigzag strip of thick paper embraces them at each end. The two plates are then faced by two other plates with films turned inwards. The bundle of four is then wrapped in thin brown paper.

Another plan, which is suitable for amateurs, is to utilise the card boxes which are sent out by dry-plate manufacturers, though it must be owned that if the boxes which can be procured from the box manufacturers, and made of thicker material and of slightly larger dimensions, be employed, the result is more satisfactory. Fig. 121 shows such a box in plan. A A shows four little blocks of wood of the height of the box glued to its sides and bottom. Between the ends of the box and the blocks little strips of cardboard can be inserted. A plate, shown by the dotted lines, is laid at the bottom of the box, face up; then slips of cardboard are inserted, and another plate, face down, inserted; then one face up, then other strips of card, and so on, till the box is full. The box should only be a very little longer than the plate, but broader. By a little ingenuity, any box which is larger than the plate can

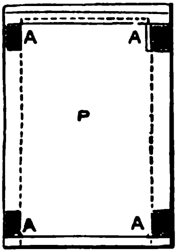

Fig. 121.

be adapted for the purpose. After the plates are thus packed, the box should be carefully wrapped up in several thicknesses of paper, one of which should be waterproof; or for this last may be substituted gutta-percha sheeting. A still more recent plan is to use soft cord, zigzagging it round the entire end of each plate, and near the edges. This is a simple plan, and should be effective.

The neatest plan that the author knows is that originated, it is believed, by Mr. Cadett. Plates of double the required size are coated, and the glass is cut through at the back. The plates are then broken through, but the film remains intact. The two halves are then folded over one another, and the unbroken film prevents movement of the plates over one another, and thus avoids any subsequent rubbing or abrasion of them.

Plates may be packed in fours or in half-dozens, enclosed in two thicknesses of orange paper. These packets are enclosed in pieces of black varnished paper, and then placed in boxes.

Boxes made of stiff millboard, and covered with varnished paper, are useful. The cover should cover both the top and sides of the boxes. They should not be too small, but be one inch longer, and ½ inch wider, inside measurement, than the plates. A depth of 1½ inches will then take one dozen plates. Edwards packs his plates in cardboard grooved boxes. They are very nice to use, but rather bulky compared with the boxes necessary to pack plates by the other methods given. They have one great advantage, however, viz. that nothing is in contact with the film. They are thus suitable for collodion dry plates as well as for gelatine dry plates. The danger with them is that dust may settle on the plates.

Some dry-plate makers separate their plates by ordinary orange paper of the size of the plate, and it answers well so long as the paper is thoroughly desiccated before being put in contact with the plates. Other makers pack face to face; but this is a bad plan except by Cadett's method just described, as the slightest grit causes scratches, and either increased development at those parts ensues, or else bare glass denuded of all emulsion.

CHAPTER XIII

MEASUREMENTS OF DENSITIES OF NEGATIVES AND DEPTH OF PRINTS

In our present state of photographic progress it is not only felt that a printable negative should be made, but also that the density which will give such print should be known. With this object in view, it may be well to point out a method by which the density of a negative or the depth of a print may be measured with great exactitude and in a very simple manner.

Fig. 122.

Suppose P to be a half-plate ferrotype or a piece of blackened card of the same size. In either of them pierce a square aperture, A, and cover it and a similar square surface, B, with white Saxe paper, and surround these two squares with black paper. If now a candle or small lamp be placed on the opposite side of the screen held vertically, the square will be illuminated when viewed from the front. If, in a darkened room, another small candle or lamp be placed in front of the screen, both A and B will be illuminated. If, however, a rod of the diameter of B be so placed that its shadow is cast on A, both squares will be still illuminated, A by the lamp at the back, and B by the lamp in the front. By moving the lamp in front nearer to or further from the screen, the two squares can be made equally bright to the eye. In this movement we see in operation the law that the amount of light falling on an object varies inversely as the square of the distance of the object from the source of light.

Thus, close behind A, we place a bit of the negative whose transparency we wish to measure; we can again make the brightness of the two squares equal; and if we have measured the distance from the screen in the two cases, we can at once find out the light coming through the piece of negative. Thus, suppose in the first case the light had to be 36 in. from the square, and in the second only 9 inches, we should know that only $\frac{1}{16}$ of light was passing through the negative, as the brightness would be inversely as the square of the distance—that is, as 1 to 16. By this plan any transparency can be measured. If the negative be very dense, the lamp at the back has to be brought nearer to the screen than when less density is in question. The diagram will show how this simple apparatus can be arranged. It is well to use it in a darkened room, since the eye is then more sensitive to gradations of light. It has sometimes been complained that the

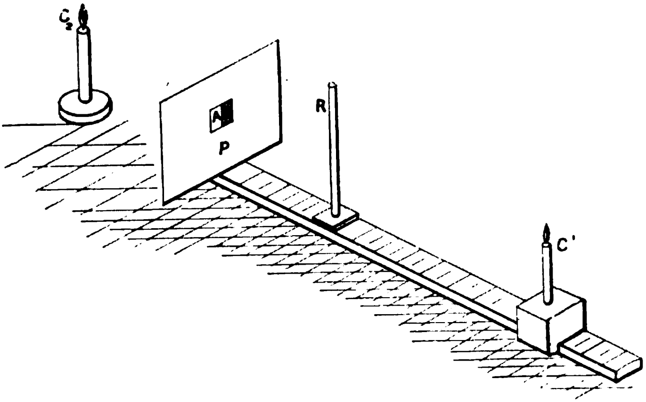

Fig. 123.

light coming through the paper is slightly tinted in comparison with that on the square illuminated by the candle or lamp C^1. There are two ways of curing this, either by slightly dyeing the paper with a pale coffee solution, or else observing through pale canary glass. With a good paper this is seldom necessary.

Supposing that, instead of the transparency of a negative, we wish to measure the blackness of a print; we can adopt a variation of this plan of measurement. A similar screen may be used, but the aperture B is cut out in this case instead of A (fig. 122), and is filled from the back with the tint which it is desired to measure. It then presents an aspect somewhat like the figure 124, C being white paper. If, now, two lamps or candles be so placed that one of them throws a shadow of a rod on one square, and the other on the other, the light throwing the shadow on the white half may be moved away till the grey light on it is equal to the grey light on the dark surface, which is illuminated by the brighter light—brighter because it is nearer to the screen. These measurements should be carried out in a darkened room, and it is well to enclose the screen in a darkened box, with an aperture cut in it so that the light only has access to the squares. The reason of this precaution is that any diffused or reflected light which may be in the room is more reflected from the white surface than from the grey, and would thus vitiate the results. To get accurate results, the white space, when the light illuminating it is shut off, should look darker than the black paper with which it is surrounded as seen in the light. The observations can be made through an aperture A cut in the side of the box (fig. 125), B being the aperture to admit the light, and R the rod to cast the shadow.

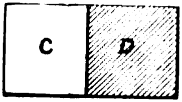

Fig. 124.

A bar divided into $\frac{1}{4}$-inches, as in the last apparatus, should be provided, and a small cradle made to carry the movable light along it, the fixed light being placed so that it illuminates all of the white surface. The first measure, of course, should be made with two white squares instead of the grey and the white, and the distance of the movable lamp from the screen is the starting-point for all the calculations. Thus, if the movable lamp had to be 15 in. away to make the two squares, when white, equally bright, but that the illumination of the white square was the same brightness as the grey square when 30 in. away, the grey tint would reflect only one-quarter of the white light of the paper.

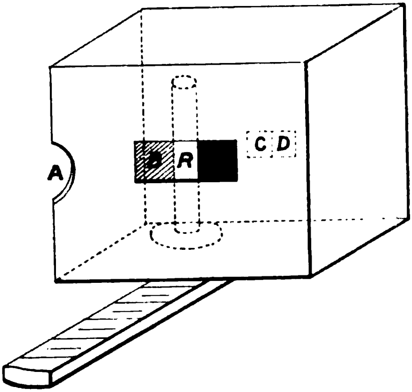

Fig. 125.

In the above methods it has been assumed that a square of density or blackness of print of some $\frac{1}{4}$ in. side has to be exposed, but the square may be reduced to $\frac{1}{16}$ inch side, or to an oblong of $\frac{1}{16}$ in. by $\frac{1}{4}$ in. if the white is reduced to the same dimensions; and the blackness can be equally well measured, especially if viewed through a magnifying glass. By an artifice of this description the density of photographic spectra can be accurately measured at fixed intervals of their length, and the curve of sensitiveness drawn, if what we may call a scale of gradations is developed on the same plate at the same time. For instance, if we wish to get the sensitiveness to the spectrum of a bromide plate, we can make a scale of density by exposing small squares along one side at different distances from a lamp for equal times, say, at 1, 2, 3, 4, 5, 6, 7, 8, etc., feet from it, and the squares of these distances (viz. 1, 4, 9, 16, 25, 36, 49, 64, etc.) will be the comparative measures of the light acting on these small squares. If, then, we expose another part of the plate to the spectrum, we shall, on developing, get the scales and the spectrum on the same plate. By measuring the density of the scale, we can derive from it the comparative sensitiveness of the plate to the different rays if the different densities of the spectrum are also measured. By this method the *sensitiveness* to the spectrum of gas-light of numerous salts of silver were measured, and the curves are more accurate than those given at page 8, which are only eye estimations of density.

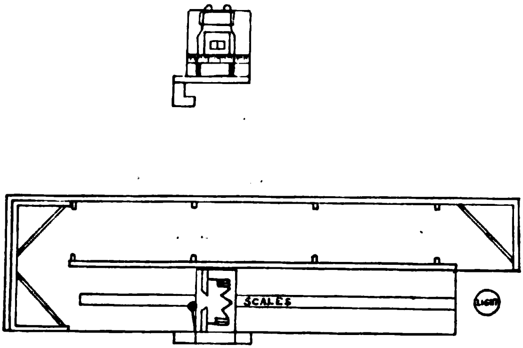

Fig. 126.

Mr. Chapman Jones has introduced a useful modification of the foregoing, using only one light for the purpose of measuring. He employs a screen as shown at fig. 124. This is placed on a carriage running on a scale as shown in fig. 126. The light shines directly upon one side of the Abney screen, and by means of three mirrors and a velvet-lined tube with diaphragms as shown, a beam is brought round to the other side of the screen. There is a rod to cut off the light from B, fig. 124.

Fig. 127.

To face p. 139.

The screen is moved till the transmitted and reflected beams appear of the same brightness, and the point on the scale where this occurs is the zero point. The density to be measured is then placed.

Instead of rotating sectors, as shown in the figure, an annulus of gelatine and black pigment as shown in fig. 127 may be employed, placing it in such a way that the slice of light falls in the direction of the centre. Thin annuluses are used in Mr. Warnerke's newest form of sensitometer. They must be graduated against rotating sectors or by other

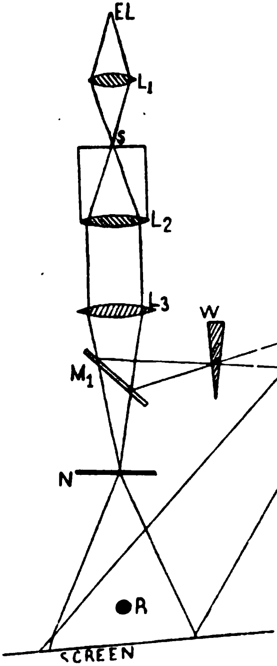

Fig. 128.

means, and a scale of degrees placed round the edge, and the degree which marks the part of the annulus used gives the proportion of light transmitted.

At the violet end also the visible rays do not give the limit of the spectrum behind the transparent part of the Abney screen, and the reflected and transmitted light are again made equal in brightness by moving the carriage. The place in the scale where this occurs is noted, and by a simple calculation, the density of the negative is arrived at. [A fuller description of the apparatus will be found in the *Photo. Journal* for December 21, 1895.]

For measuring small sections of negatives, such as the negatives of the spectrum, the following plan is adopted by the writer :—

E L (fig. 128) is an electric light; an image of the carbon from it is thrown by a lens L^1 on to S, a sector. L^2 is a lens placed at its focal length from S, so that the rays run parallel and fall on L^3, a lens which forms an image of the sector S on N, the negative narrow portions of which have to be measured. M^1 is a plain piece of glass which reflects a percentage of light on to M^2, a silvered mirror, and which then falls on the same screen as the direct rays. A rod, R, casts two shadows side by side. A black glass wedge, W, or an annulus as in fig. 127, is inserted where the rays * cross in the reflected beam, or rotating sectors are placed in the path of this beam, the apertures of which can be altered at pleasure, and the two shadows are made equally bright. The negative is moved along the image of the slit as required, and so transparency measurements of each portion can be made.

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* The rays passing through M_1 and N, fig. 128, to the screen ought to be shown as straight lines, and not altered in direction after passing through N.

CHAPTER XIV

MEASURING THE TRANSPARENCY, THE SPEED AND GRADATION OF PLATES

PERHAPS the most difficult part of the gelatine process is to gauge the right exposure to be given in the camera. The time during which the lens should be uncovered varies between the hundredth part of a second and a couple of hours; the exposure depending upon, 1st, the sensitiveness of the plate; 2nd, the photographic intensity of light; 3rd, the nature of the view; and 4th, the available aperture of the lens. The sensitiveness of a plate is rather a vague term, and has been translated in various ways. Probably a good definition of it is the sensitiveness to very feeble intensities of light which correspond to the detail in dark shadows of a picture. For this purpose a very useful piece of apparatus is Warnerke's sensitometer (fig. 129), which can be obtained commercially. It consists of a piece of glass, A, covered with squares of pigmented gelatine, each square having painted on it an opaque number. This sensitometer requires no measurement of the opacities of the different spaces, so is convenient. The light penetrating through one of these squares is about one-third less intense than the number immediately preceding it. By exposing a plate behind such a sensitometer to a constant light—such as a phosphorescent tablet, E, which is sent out with the instrument, or a candle which has burnt five minutes, and placed at a fixed distance from the apparatus during exposure—the relative rapidities of any plates may be ascertained. The tablet A fits into a dark slide, B. In C is an opening through which the phosphorescent tablet can shine when the board, D, is pulled up. A plate, or a piece of a plate, rests on A when in position, and then the back is placed on it. The phosphorescent plate, E, is exposed to the light from magnesium ribbon, an inch of the latter being sufficient to give full illumination to it. It is placed in position as above indicated, and after a minute has elapsed from the time of burning the wire, D is pulled out and exposure given for half a minute; then D is closed, and the plate taken out and developed. The following table, compiled by Mr. Cadett, gives the comparative sensitiveness of plates which show different numbers :—

Fig. 129.

	Number of times more sensitive than										
	25	24	23	22	21	20	19	18	17	16	15
25	1	1⅓	1¾	2⅓	3	4	5	7	9	12	16
24		1	1⅓	1¾	2⅓	3	4	5	7	9	12
23			1	1⅓	1¾	2⅓	3	4	5	7	9
22				1	1⅓	1¾	2⅓	3	4	5	7
21					1	1⅓	1¾	2⅓	3	4	5
20						1	1⅓	1¾	2⅓	3	4
19							1	1⅓	1¾	2⅓	3
18								1	1⅓	1¾	2⅓
17									1	1⅓	1¾
16										1	1⅓
15											1

The numbers down to 15 only are given, this being more than sufficient for comparison of most plates. Supposing it is desired to compare the rapidity of two plates showing different numbers, look for the higher number in the column on the left side of the table, and the lower one in the top horizontal row of numbers; then run the eye along the line of the number in the left-hand column until you come to the figure under the lower number; the figure will then show the number of times more sensitive is the plate showing the higher number than the plate showing the lower number. For instance, a plate showing 21 is four times more sensitive than one showing 16; one showing 20 is three times more sensitive than one showing 16, and so on; that is, the exposure with the more rapid plates may be diminished accordingly.

Plates prepared by the formula given in Chapter XI. should show from 18 to 25, according to the length of time during which the emulsion is boiled, and also according to the time it is kept after boiling.* A plate on which the last sensitometer number visible after development is 23, is very rapid, and should have ample density at the same time. When using a Dallmeyer rapid rectilinear lens with No. 5 stop, which has an aperture of about one-fortieth of the focal length, such a plate exposed on a landscape in spring-time, when the light is good, and if the view is an open one with trees not too close, should be impressed with a fully exposed image in half a second. The same plate with the largest stop should give an equally well-exposed picture in the $\frac{1}{25}$ part of a second.

What can be done on a plate of a known rapidity requires a further knowledge regarding its qualities, and that is its gradation. If a plate be exposed on a sensitometer sufficiently long, it will be found that a limit of density is reached; that is, that after a certain point of exposure no further density will be developed. The number of squares between the point where this limit is reached and where no deposit is apparent will vary according to the kind of plate employed. This entails two things: 1st, that the plate, if more thickly coated, would be more rapid, as the light that penetrates would be arrested and utilised in forming the image; and 2nd, that the maximum density obtainable with the particular

* The sensitiveness increases nearly three times by keeping a couple of days before coating the plates, particularly if it be occasionally melted.

emulsion used is variable. A very good example of the effect that is obtained by a varying thickness of film is that of exposing some half-dozen films of the Eastman type behind one another in a frame for varying times and developing all in the same dish for the same time, and then fixing them and measuring the opacities. The following are the results of an absolute experiment:—

Exposure	Transparencies of					
	1st Film	2nd Film	3rd Film	4th Film	5th Film	6th Film
Min. Sec.						
42.40	1.62	2.37	6.64	21.3	42	86.9
21.20	1.75	3.45	12.9	45.2	83	98
10.40	1.92	5.79	32.4	70.0	92	99.5
5.20	2.72	12.5	52.0	88.8	99	100.0
2.40	3.96	25.0	74.5	99.0	100.0	
1.20	7.2	48.1	88.8	100.0		
40	14.3	70.0	100.0			
20	30.4	86.00				
10	59.0	99.00				
5	82.0	100.00				
2.5	100.0					

It will be seen that the thickness of the film has a great deal to say to the opacity. If the thickness of the film had been equal to two of the kodak films the transparence of the films might have been as shown in No. I. of the next table, and if of the thickness of six films it might have been shown in No. II. It is not to be implied that these figures are absolutely the transparencies, because the developer had free access to all the films at one time.

Exposure	Transparency	
	No. I. two films thickness	No. II. six films thickness
Min. Sec.		
42.40	.030	.00023
21.20	.060	.0033
10.40	.111	.0226
5.20	.346	.126
2.40	.990	.789
1.20	3.463	3.02
40	10.010	9.91
20	26.144	26.00
10	53.60	58·60
5	82.00	82·00
2·5	100.00	100

If a plate be starved of sensitive material, it will be found, when using the sensitometer, that the gradation rarely exceeds 15 numbers between maximum opacity and absence of all visible deposit; whereas, if the same material were used and a thicker coating given, the range of gradation would be increased to 18 or even 20 numbers. With a plate prepared by the formula given, the range is often 22, and sometimes 25. A good plate should have as long a range of gradation as possible, as the longer it is, the better will the details in shadows and high-lights be expressed. If we take a range of 15 numbers only, it means that if a high-light is strong enough to impress the plate just as much as to develop with the maximum density, the light, which is only $\frac{1}{32}$ of this photographic intensity, will fail to show on the plate. If a plate show a gradation of 22, it will just not be impressed by a light $\frac{1}{128}$ of the same; that is, details in the shadows will be much more pronounced in the latter case than in the former. It may be said that by giving a more prolonged exposure with the former plate, the detail in the shadows will be equally well brought out. This is quite true; but suppose the exposure be so prolonged as to do this, we must consider what would happen in the high-lights. This would happen: all the different gradations of light in the print would be expressed in the negative by the same density, and probably there would be no difference seen in the print between the highest light and that only one-half of its value. As a matter of fact, it is usually attempted to expose so as to lose a little detail in the high-lights and a little in the shadows, keeping the half-tones full of detail. But it must be recollected that the most perfect negative is that in which the gradation is greatest—that is, one taken on a plate which shows the greatest range between the highest density and bare glass. In *any* case, the amount of detail will never be strictly comparable with the amount found in nature, even when the latter is converted into photographic intensity of light. This will be apparent if we examine the annexed figures. It will be necessary to describe in what way they were arrived at. In this case a sensitometer was used of a different construction to Warnerke's, it being a pattern brought forward by Mr. Spurge, to whom the writer is indebted for its use. It may be described as an instrument admitting different quantities of the same light to different square pieces of a plate, the quantity being regulated by using apertures of different sizes to admit it, each successive aperture increasing by 2⅓; if the aperture of one hole which admits the light be 1, the next

TRANSPARENCY OF DEPOSIT.

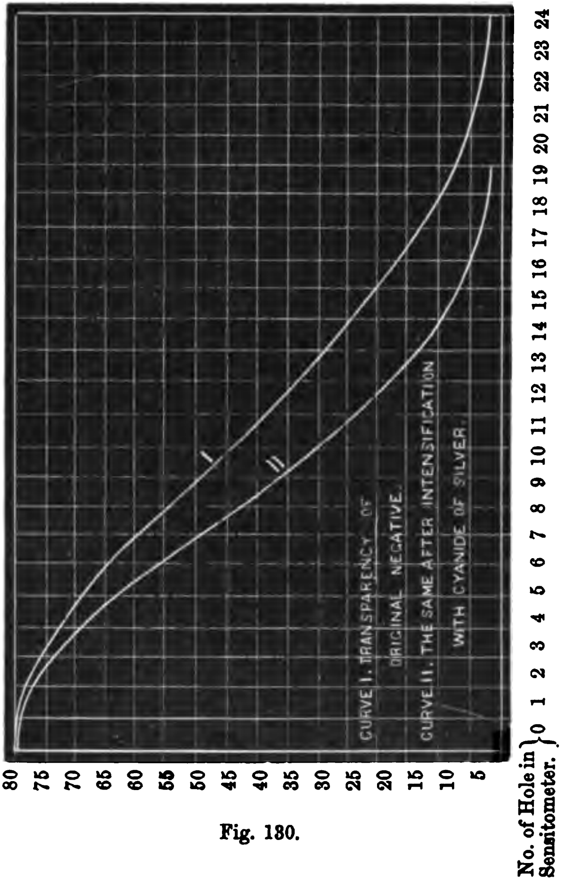

Fig. 180.

would be 1·25, the next 1·59, and the third 2, and so on. Thus, every third hole doubles the quantity of light admitted. There are 30 holes of different apertures, and a quarter-plate very evenly coated was exposed to a surface uniformly lighted, and then developed. The transparency of these squares of different density was measured by means of the instrument shown in Chapter XIII. The results are shown in the diagram Curve I., the transparency being given by height of the curve, and the number of the holes being the base of the curve. It will be seen that each end of the curve, where the variations of intensity in the shadows and in the high-lights are represented, is very flat—that is, they are not expressed in transparency in the same proportion that the light producing the opacity is expressed.

Curve II., to which we shall refer again, is the same negative intensified with mercury and silver. If the trouble be taken to construct a similar kind of curve, by taking the transparency of each square and seeing what density would be obtained when similar light for the same time is allowed to fall on a similar plate, it will be seen that it is impracticable ever to reproduce the same gradation of light which originally acted to produce the sensitometer curve. Hence we may assume that a print can never give an exact representation of the original light acting on a plate.

For those who do not possess a sensitometer, a very good substitute may be made by exposing, in an ordinary slide, different small squares of a plate for different lengths of time. This can be readily done by cutting a square in a piece of card, and placing it in front of the slide, and, instead of closing the slide after every exposure, merely to shift the card along, covering the square hole with a black card whilst the shift is being made. With a good plate, the following exposures made to a small paraffin lamp placed six feet off the plate, would give an excellent scale of density: 6, 9, 13, 18, 26, 32, 36, 48, 80, 128, and 200 seconds. This is assuming that the last density gives almost as great opacity as 170 seconds will do. These squares should correspond closely to eleven squares of the sensitometers described. A very useful form for such a sensitometer to take is to cut out four or five squares in the card, fairly close together, and in a line with one another, as by this means four or five rows of squares of equally increasing density are produced. This is most useful in comparing different plates together, or the sensitiveness of different printing processes. There is one point to be attended to, however, in the manufacture of these home-made sensitometers, which is, that the development of these plates should take place either with ferrous oxalate, or with alkaline developer to which sulphite of soda has been added to secure freedom from all stain. With either of these developers, the photographic transparency of the squares will be found to correspond with the optical transparency as measured by the apparatus described.

Messrs. Hurter and Driffield introduced a new system of registering the speed of a plate. Different portions of a plate (small squares) were exposed to the light of a candle at a metre distance, and for 1, 2, 4, etc., seconds, and after development the *densities* of the spaces were measured, the density being defined by them as the logarithm of the opacity, which is the inverse of the transparency of the deposit. Such densities are plotted as ordinates, the time exposures being the abscissæ. They found that from a moderate density to extreme densities, the extremities of the ordinates fell in a straight line. This line was produced, and the place where it cut the abscissæ was the measure of sensitiveness. Sensitiveness measured on that scale is directly proportional to the number given. Thus a brand of plates marked 200 has double the sensitiveness of one marked 100.

A very ingenious aid to exposure has been brought out by Mr. Alfred Watkins, which he terms an exposure-meter; and there is no doubt that many have found it most useful in helping them to judge of their exposures. It contains, in fact, a calculating machine for putting together all the factors which have to be considered in exposing a plate. The accompanying cut will show the form it takes; it is about one-half of full size. The factors which it takes into account are: A, the actinic value of the light falling on the subject; P, the sensitiveness of the plate; S, the colour or character of the subject; and D, the diaphragm or stop used. The second and the last are the factors which alone are independent of judgment. S has to be submitted to the test of knowledge of the photographer. The value of the light is claimed to be known by exposing sensitive paper with its face in the same direction as the light falling on the subject. This we hold to be a mistake, as all exposures should be made for the shadows, and it is the sky which illuminates these if they are open, and in using it, the writer has found that it is better to point it towards the part of the sky at right angles to the direction of the sunlight, if there be any. The value of sunlight should scarcely be considered, which would not be the case in a landscape if the directions be carried out. The variation in exposure that must be given according to the judged value of S will be sure to be enormous. Thus, for sky or sea, S = 10; for white objects in which detail is required, S = 25; open landscape, S = 50; for average landscape with foreground buildings, and everything of average colour, S = 100; if dark, yellowish, or reddish objects, S = 200; and very dark objects, S = 300. As full directions are given with each instrument, we need not enter into these matters with greater detail. We only quote this to show, that even with an exposure-meter, the judgment of the operator is an important factor.

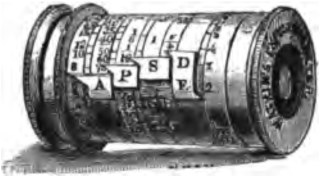

Fig. 131.

CHAPTER XV

EXPOSURE OF THE GELATINE PLATE

When plates are sent out by makers they usually contain some indication of their speed on some arbitrary scale. Thus we hear of plates being forty times more rapid than a wet plate, or that a plate is twenty-four on Warnerke's sensitometer, or that it is 150 H and D, and so on. These indications may or may not be absolutely right, but they give, at all events, a rough approximation of what may be expected. It may be said with some degree of truth that a plate which has one of the above factors on a bright day in spring with a fairly open landscape will require an exposure of half a second if a stop of *f*/32 be employed; and for such an exposure putting on and off the cap is not a good plan. It is better to have a time shutter such as has been described, or else a flap shutter inside the camera behind the lens such as Cadett's. The only alternative is to use a slow plate, such, for instance, as one which shows about 15 on Warnerke's scale, where the time will be increased, and allow the cap to be used. Whatever may be the system of exposure, the following remarks will apply. (Mr. Watkins issues a list of plate speeds in connection with his actinometer described in the last chapter, which will prove useful to the student.)

The plate should never see any light which is the least injurious to it, and care should be taken, when placing it in a slide, to use light such as is given in the chapter on the Dark-Room, or else to use a proper lantern in a darkened room. The slides should close perfectly, and the hinges of the front should be of leather, as introduced by Meagher. The leather may be found to cause marking in the plates if they are left long in the slides. The leather should be rubbed with solid paraffin, which will prevent the evil.

Very careful workers fit the slides in open-ended sheaths of cardboard, when filled, for protection, except when *in situ* in the camera. When in the camera the slide should be covered with the focussing cloth, and the front withdrawn whilst beneath it. This prevents the access of any stray light to the plate.

The lens should also be examined to see that no reflected light enters though the aperture made for the diaphragms. This can be ascertained by capping the lens, turning back the focussing screen, and placing the head beneath the focussing cloth. A piece of black velvet with an elastic band attached may be used to cover over the diaphragm aperture should any light appear.

Another point to see to is that light coming through the lens is not reflected on to the plate from the inside of the camera. This is most likely to occur when a lens is used which will cover a larger plate than that which the camera is made to take. In such a case a diaphragm, placed behind the lens, of such a size and shape that the image will just cover the plate, is effective. The inside of the camera should be well blackened, but the black should be dead, and not shiny. In fine, too much care cannot be taken to avoid the slightest chance of any light striking any part of the plate except through the proper aperture of the lens.

The same precautions should be taken after exposure as well. Remember it is dangerous to expose a slide to the full effect of sunlight. Give a full exposure, but not an excessive one. A plate properly coated with the emulsion given in Chapter XI. can be controlled in development if it has received twelve times too much exposure, but more than this is almost uncontrollable. With a plate starved of silver and without iodide, the exposure must take place within very close limits if a passable negative is to be obtained. An under-exposed plate is useless. It will thus be seen that judgment, to be got only by practice, is required to secure good results, and a novice should not be astonished if two out of three plates he exposes yield unprintable negatives. A very few words must be said regarding the setting up of the camera for landscape subjects. The camera-stand must be firmly placed, and not be liable to sink into the ground. If photographing on ice, the stand should be left *in situ* some few minutes before an exposure is attempted, as the warmth of the points of the legs melts the ice, and sometimes a movement will take place in consequence during the exposure. It is better to use the rising front than to tilt the camera, though this is not always possible. If tilted, the swing back should be employed and the ground glass be on a vertical plane. It is seldom good photography, from an artistic point of view, for a marked horizon line to cut the picture in half. It is well to keep it above or below the centre line. The position must depend upon the subject. If the principal part to be photographed is distant, it should be below, but if the foreground and middle distance is the object it may be kept above.

One error which an amateur is very liable to make is in the introduction of figures into the photograph. He will often place them so that it can scarcely be guessed whether it is the figures or the landscape which is under portrayal. The figures in a landscape should only be subsidiary, but should be larger than to appear merely black dots. The reader is referred to Robinson's *Pictorial Effect in Photography* for further advice on the artistic side.

CHAPTER XVI

ALKALINE DEVELOPMENT OF THE PLATE

DEVELOPMENT of a gelatine plate is, in reality, an art and science combined. The art consists in getting proper gradation, and the science in mixing your solutions to obtain it. There are only two kinds of exposed plates which deserve attention at all—one when it is exactly timed rightly, and the other when it is moderately over-exposed. An under-exposed picture should be washed off as quickly as possible, or framed for the benefit of beginners. Our own practice in developing is only to make up three solutions: one of bromide of potassium, another of ammonia, the third of sulphite of soda, and to add dry pyrogallic acid to the measured quantities. The formula stands thus :—

1.—Pyrogallic acid	dry	
2.—Potassium bromide	20 grains ...	20 *parts*
Water*	1 ounce ...	440 ,,
3.—Ammonia (·880)	1 drachm ...	1 *part*
Water	9 drachms ...	9 *parts*
4.—Sulphite of soda	a saturated solution	

The normal developer is made as follows :—

No. 2	1 drachm ...	55 *parts*
No. 3	1 ,, ...	55 ,,
No. 4	1 ,, ...	55 ,,
1.—Pyrogallic acid	3 grains ...	3 ,,

* Water to make up to 2 ounces (880 *parts*).

To measure out the pyrogallic acid, we use a strip of glass,

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* For the water recommended, see further on in this chapter.

about ½-in. wide, and after one or two trials approximately three grains can be taken out. Some use a bone salt-spoon for the same purpose. If distilled water be used with the pyrogallic acid, it will only slightly discolour during development. The method of applying this developer is the same as that given below. The next developer meets with the approval of many.

The following solutions should be made up:—

* P.—Pyrogallic acid	... ...	50 grains ...	50 *parts*
Sodium sulphite	... ...	150 ,, ...	150 ,,
Citric acid	... ...	10 ,, ...	10 ,,
Water	... ...	1 ounce ...	440 ,,
B.—Potassium bromide	... ...	50 grains ...	50 ,,
Water	... ...	1 ounce ...	440 ,,
A.—Ammonia (·880)	... ...	2 drachms	110 ,,
Water	... ...	2¼ ounces ...	990 ,,

These nearly correspond to 10 per cent. solutions.

The plate is usually developed by taking of the above—

P	... ...	20 minims ...	20 *parts*
B	... ...	30 ,, ...	30 ,,
A	... ...	60 ,, ...	60 ,,
Water	... ...	2 ounces ...	880 ,,

Such a developer contains approximately 1 grain pyrogallic acid, 1¾ grains of potassium bromide, and 3¼ minims of ammonia (·880) to the ounce of mixed developer.

The plate is put in a flat dish, and the solution flowed over at once, though for novices the plate may be soaked in water for a minute previously, the plate being drained before the application of the developer. The development should be carried on till the image is well seen at the back of the plate, or till the deepest shadows begin to assume a grey tint, in which case the development must be stopped and the plate fixed, leaving subsequent intensity to be gained, if necessary, in the intensifying process.

When a plate is properly exposed—that is, when the exposure has been sufficient to allow development of detail in the shadows without choking of the high-lights—either of the above developers may be applied in the proportions given, but

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* The sulphite should be first dissolved in the water, next the citric acid, and finally the pyrogallic acid.

if exposure has been too prolonged, either by intention or by accident, a different course should be adopted. For instance, if distant snow mountains or intensely white clouds and near deep shadows may have to be portrayed on the negative, exposure should be given for the latter, which would mean that the detail in the clouds would be choked if the ordinary procedure were adopted.

In this case the proportions should be modified, and as an example of how such modification should be effected, an example will be taken from the developer first given.

The mixture would be made as follows :—

No. 1	1 grain	1 *part*
No. 2	2 drachms	100 *parts*
No. 3	10 minims	9 ,,
No. 4	1 drachm	55 ,,
Water	2 ounces	880 ,,

This developer contains approximately ½ grain pyrogallic acid, 2¾ grains potassium bromide, and ½ minim of ammonia to the ounce of mixed developer.

This developer is applied to the plate, and the image will only appear very slowly indeed, and may take ten minutes before all the detail is seen by reflected light, but the development must proceed until the point that, whilst the deepest shadows still remain unveiled, the next deepest shadows appear slightly grey from development. Such a plate should not be carried any further with the developer. It should be fixed, and well washed and dried. On examining it, it will be found that, as it stands, it is perfectly useless for printing from, but that there is a gradation in the high-lights, and also faint detail in the shadows. If, however, it be intensified by some of the formulæ given later, it will be found that such a negative will give prints which are excellent in every way. A reference to the figure at page 146 will show why this is. Curve 1 there shown is, it is true, a sensitometer curve, but it has an empyric standard of intensity, and it is quite feasible to take the unit of light, say, of the landscape, such that the highest light shall be represented by a part of the curve which has a transparency of, say, $\frac{34}{80}$ at 12 on the scale, instead of $\frac{3}{80}$ at 24 on the scale ; in other words, we may utilise the portion of the curve between 0 and 12, instead of between 0 and 24. Curve 2 shows that, when intensified, the densest part will then only transmit $\frac{18}{80}$, instead of the $\frac{34}{80}$; in other words, the negative has improved in printing qualities. The details in the shadows represented, say, from 0 to 2 of the scale, are improved in density, and also the gradation in the highest lights, which may, perhaps, be represented by the scale 12 to 9. The intensification can be made to give more contrasts if desired. What has been done in this case is to make a small sacrifice in the range of gradation of the half-tones, but such is better than sacrificing the details in the high-lights or the shadows. Messrs. Hurter and Driffield have asserted, after careful measurements, that no alteration can be made in the relative densities of a negative, but it must be recollected that the term density, as used by them, is not the opacity of the negative, but the amount of silver deposited (which is the logarithm of the opacity).

The slow development given above does not vitiate this statement; it merely puts in the hands of the operator the power of readily arresting the development at any required stage, and getting opacity by subsequent intensification.

The question of the development of instantaneous pictures is one which requires very matured skill. One cannot get out of a plate what is not there, and yet there is often detail on a plate which scarcely appears to the eye to be present. Of one thing we may be certain, that most pictures of this class are looked upon as a *tour de force*, and deficiency in detail, which would not be tolerated in an ordinary view, escapes the unfavourable criticism which it more often than not deserves. An instantaneous picture so called is frequently little better than a silhouette, and detail in the shadows is most frequently non-existent, except the lighting be exceptionally good, and the time of exposure reckoned in $\frac{1}{10}$ths of seconds rather than in $\frac{1}{100}$ths. Suppose that, in a good light, an open view can be taken with the rapid rectilinear lens in one second, using a stop *f*/40; then, in order to take the same view in the $\frac{1}{10}$th of a second, the stop would have to be increased to about *f*/13, which is a stop 1 in. aperture, if the focal length be 13 in., which is a large-sized stop. If $\frac{1}{25}$ should be given, then the stop would have to be *f*/8, which is more than the full aperture with some lenses. It should be remembered that, with a full aperture, only the central part of the field has the best illumination, both illumination and definition falling off very rapidly towards the margins.

Most instantaneous views, except, as said before, they are very exceptionally lighted, suffer in one or other of these respects, and the only thing to do is to make as much as possible of an exposed plate. If the definition have been sacrificed for the sake of the exposure, then the normal developer given above may be used; but if the exposure is suspected of being short, then resort must be had to development in the way that the late Col. Stuart Wortley first advocated, though, in view of the results obtained by Hurter and Driffield, it may be supposed that something must be sacrificed, either the details in high-lights, or else in the shadows. In our own experience, the method proposed seems to possess a certain advantage, and, knowing that the same kind of procedure held good in the days of collodion dry plates, when a phantom image could be first obtained and then be built up, the prejudice of early experience is not readily eliminated.

The formula that is advocated is as follows. Take—

No. 3	1 drachm	55 *parts*
Water	2 ounces	880 „

and soak the plate in this for a couple of minutes, and then add to the developing cup—

No. 2	1 drachm	55 *parts*
No. 4	1 „	55 „
No. 1	1½ grains	1½ „

The developer will now contain approximately ¾ grain pyrogallic acid, 1½ grains potassium bromide, and 3 minims of ammonia to the ounce of developer.

The image will begin to flash out and attain a certain amount of density, and this development must be continued until the high-lights begin to choke, when the developer must be washed off, and the negative be fixed. Should development flag at all, another 1½ grains of pyrogallic acid may be added.

There is a wrinkle which the writer has often used to bring out detail without choking the high-lights, which is when the image begins to appear, to take the plate out of the developing dish and drain it, and leave it for a couple of minutes. The developer in the film acts its part, but it will be noticed that it is acting under different conditions to those which exist when the solutions are constantly renewed in the film. The part in the film where the high-lights are becomes rapidly exhausted, but that in the shadows only gets exhausted as details appear; hence, the detail can be built up without any material building up of the high-lights. It must, however, be recollected that if the detail has not been impressed by sufficient exposure, nothing will bring it out.

Sometimes, brushing the parts of shadows with a stronger solution of ammonia, whilst out of the dish, will bring out detail if it is developable, and if the photographer be not a mere machine he will, to get a pleasing picture, adopt such an artifice, which is a deal more legitimate than retouching the negative. Those who have worked the old calotype process will remember that a brushful of solution in the hands of the manipulator gave him a power which made him a rival of the artist painter.

The following has been recommended with some kinds of slow plates:—

No. I.—Pyrogallic acid	2 grains	1 *part*
Water	1 ounce	220 *parts*

used freshly mixed.

No. II.—Potassium bromide	15 grains	15 *parts*
Water	1 ounce	440 ,,

No. III.—Ammonia (·880)	1 drachm	1 *part*
Water	1 ounce	8 *parts*

The plate is softened for one minute in water, 1 ounce of No. I. is applied for one minute, and then three minims of II. and III. are dropped into the developing cup, and the pyrogallic solution poured back. This is again poured on, and the image develops. When development flags, 3 minims more of Nos. II. and III. are again added till sufficient density is obtained.

Some people recommend that the dish be not rocked to and fro; but we think it better to give a gentle motion to the liquid, as we have found that sometimes fog and mottling is induced by not so doing. For securing this motion, several contrivances are extant. Amongst others is one by Dr. Eder. The apparatus is, as fig. 132 indicates, screwed upon a table, and it consists of an iron plate having two V-pieces, in which work the knife-edges of the pendulum. Over these knife-edges is a small round platform, upon which the dish stands, and there are steadying pieces which slide on iron rods, as shown in the figure. When once the heavy iron pendulum is set in motion, it remains swinging for a long time. It is said that sometimes this regular motion causes streaks of varying intensity to be produced.

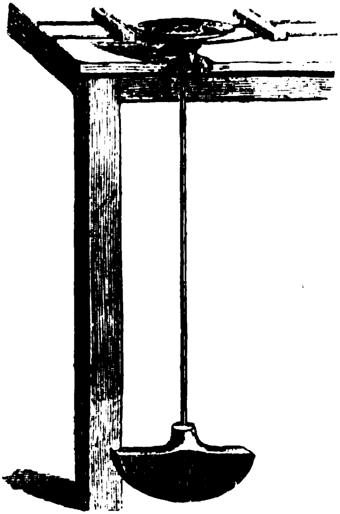
Fig. 132.

For most of the rapid plates to be found in the market, and also for plates prepared as in Chapter XI., the following may be used :—

No. I.—Ammonia (·880) ...	1 ounce	...	440 *parts*
Potassium bromide	60 grains	...	60 ,,
Water	3 ounces	...	1300 ,,

No. II.—Pyrogallic acid	...	3 grains ...	3 *parts*
Water	... ...	2 ounces ...	880 „

The plate is soaked in water for a minute, when the water is poured off, and No. II. substituted. From 15 to 20 drops of No. I. are poured into the cup, No. I. returned into it, and applied again. The plate develops rapidly. For our own part, we like to add No. I. at two intervals of time, as the development is more under control.

In the formula we gave (page 154), it will be seen that sulphite of soda is used. It is added to prevent discolouration of the pyrogallic acid, which is a readily oxidisable body. Some photographers, however, add nitric acid or citric acid to the pyrogallic acid for the same purpose. When using these last, however, it must be remembered that a certain amount of ammonia is thereby neutralised. If nitric acid be used, 4 minims will be sufficient to keep 60 grains of pyrogallic acid free from colour; if citric acid, about 10 grains should be used.

For removing the yellow colour so often seen in alkaline developed gelatine negatives, also for the use of the alum bath to avoid frilling, see the chapter on "Defects in Gelatine Negatives."

There is always a certain amount of quackery amongst photographers, and, as the general public are ready to believe in a patent medicine, so many photographers are ready to add anything to their developers which differs from that ordinarily in use. The use of meta-bisulphite is a case in point. It is not better than sulphite, but it has the advantage of costing more, and is certainly a purer compound than the sulphite of commerce. We give a formula in which this ingredient forms a part:—

No. I.—Pyrogallic acid...	...	100 grains ...	100 *parts*
Ammonium bromide	...	50 „ ...	50 „
Meta-bisulphite of potash		100 „ ...	100 „
Water	...	3½ ounces ...	1540 „

The bromide and meta-bisulphite are first added to the water and dissolved, and then the pyrogallic acid is added.

No. II.—Ammonia ...	... ...	1 *part*
Water ...	... ...	64 *parts*

It is convenient to make up a third solution of No. I. by taking—

No. III.—No. I. ...	... ...	1½ ounces ...	1½ *part*
Water ...	... ...	18½ ,, ...	18½ *parts*

Nos. II. and III. are mixed in equal proportions to form the developing solution.

The writer does not believe in what may be called "two-solution" developers; it is always better, in his idea, to have three solutions, the proportions of which can be varied. A developer such as the above is useful when precisely the right exposure is given; but it leaves the operator as a mere mechanical agent of the dry-plate manufacturer as far as development is concerned.

Soda and Potash Developer.—Some photographers like to substitute carbonate of soda and potash for ammonia. It must be borne in mind that these are not the bicarbonates, which are practically ineffective. The following is a good general formula:—

I.—Pyrogallic acid (dry)... ...	3 grains ...	3 *parts*
II.—Saturated solution of dry monocarbonate of soda or potash ...	1 drachm ...	55 ,,
III.—Potassium bromide solution (10 grains to the ounce, 2 *per cent.*)	1 to 20 minims ...	1 *to* 20 ,,
IV.—Water	2 ounces ...	880 ,,

It may be objected that the strength of a saturated solution of the alkaline carbonates varies according to the temperature, and this is no doubt true, but not sufficiently to be of any importance. Some use sulphite of soda with the above, No. 2, and there is no objection to this course. About ten grains of it to the ounce of saturated carbonates is sufficient to ensure immunity from yellow stains. It is the yellow stain which is the greatest objection to these developers, though, if the carbonates are pure, there is less liability to it; and even if there be a stain, a 10-grain to the ounce of water solution of citric acid after washing the plate should entirely eliminate it.

A "two-solution" potash developer may here be given :—

No. I.—	Pyrogallic acid	100 grains	100 *parts*
	Meta-bisulphite of potash	4 ,,	4 ,,
	Water	3½ ounces	1540 ,,
No. II.—	Potassium carbonate (pure)	100 grains	100 ,,
	Sulphite of soda (pure)	120 ,,	120 ,,
	Water	2 ounces	880 ,,

To every part of No. 1 seven parts of No. 2 are added, and an equal bulk of water. In cases of over-exposure, a few drops of a ten per cent. solution (44 grains to the ounce of water) of potassium bromide may be added; and in case of under-exposure, the addition of a similar quantity of a ten per cent. solution of caustic potash may aid matters.

It would be possible to fill pages of this book with variations of formulæ, but we are quite certain that any plate will develop properly with the first alkaline formula given, if it will develop at all.

In making up all developers pure water is recommended. One of the difficulties in obtaining spotless negatives is that due to using ordinary tap-water. When used it is very apt to give air-bells, which cling most pertinaciously to the plate. Such air-bells prevent development on that particular part of the plate to which they cling, and on fixing, the negative is marred by transparent spots. With pure rain or ice water these air-bells do not form. We recommend, therefore, that distilled water be used; failing that, filtered rain-water; and again, failing that, boiled tap-water, which will expel most of the carbonate of lime and dissolved air. As to the use of pure sulphite, that is also to be recommended, but is not necessary. If sulphuric acid be added to an alkaline sample till the solution evolves sulphurous smell, such may be used. The same may be said of the mono-carbonate of soda, only in this case carbonic acid will be liberated, and not sulphurous acid. The great point to aim at is to neutralise any free alkali.

A golden maxim to remember, and which cannot be too often repeated, is to give plenty of exposure, and to use a very small proportion of alkali in the developer to begin with. In some cases, where we have had great over-exposure, we have used only one-tenth of the normal amount, and double the normal amount of bromide, and worked up the negative to proper density by long-continued application. Half-an-hour to three-quarters is not an excessive time in which to complete development with such over-exposed plates. The patience required is amply repaid by the results obtained.

Hydrokinone Developer.—When the author of this work first discovered the developing power of hydrokinone, it was not possible to employ it, except for experiments, owing to the prohibitory price that was put upon it. Manufacturing chemists, however, took the matter in hand, and now it can be obtained cheaply and of excellent quality. It is a great favourite with many photographers, owing to the beautiful colour of the negatives and the clean way in which they develop. There have been many formulæ propounded for its use, but the following are as satisfactory as any :—

No. I.—Hydrokinone	...	4 grains ...	4 *parts*
Water	...	4 ounces ...	1760 „
No. II.—Ammonia ...	...	1 drachm ...	55 „
Water	...	9 drachms	500 „

To every 32 parts of No. 1, 1 part of No. 2 is added to obtain full intensity, The ammonia may be added gradually —that is, by beginning to develop with ¼ part first. The colour of the negatives by this developer is excellent, and the solution remains light. A further modification is as follows:—

No. I.—Hydrokinone ...	...	20 grains ...	2 *parts*
Water ...	...	10 ounces ...	440 „

No. II.—Carbonate of potash, a saturated solution in water.

To each 8 parts of No. 1, 1 part of No. 2 is added, and about ⅛ part of a 2 per cent. solution of chloride of sodium.

Some photographers like to use sulphite with it, in which case the following formula—which is excellent for instantaneous work—may be employed :—

No. I.—Hydrokinone	...	90 grains ...	90 *parts*
Meta-bisulphite of potassium, or sulphite of soda		90 „ ...	90 „
Water	...	10 ounces ...	4400 „
No. II.—Sodium hydrate ...	...	1 ounce ...	440 „

One part of No. I. is mixed with one part of No. II., and six parts of water are added. With all these formulæ the image should appear fairly rapidly and gain density. In cases of strong contrast, the No. I. in each mixture should be reduced to half of the strength. It will be noticed that no bromide is added to the developer, the reason being that it acts very energetically as a restraining agent—too much so, in fact. In case a restrainer be required, the addition of one part of a saturated solution of common salt to fifty of the mixed developer will be found efficacious. The sodium chloride has a much milder restraining influence than the bromides employed in the ordinary alkaline developer.

Development with Eikonogen.—The following formula for development with eikonogen has been recommended by Mr. Lyonel Clark :—

Eikonogen	100 grains	10 *parts*
Sodium sulphite	200 ,,	20 ,,
Sodium carbonate	100 ,,	10 ,,
Potassium bromide	5 ,,	½ *part*
Water	10 ounces	440 *parts*

This is a good formula for instantaneous pictures, and gives beautifully bright pictures with no stain or fog, and can be recommended for the purpose. The small quantity of bromide added seems to give a greater density to the negative than when it is omitted, and it should be used as a rule. For very rapid exposures the negative may be developed without it. There are many formulæ which have been given for the use of eikonogen, but it is thought that the two following will suit any requirements. Mr. Chapman Jones recommends as follows :—

Eikonogen	25 grains	25 *parts*
Sodium sulphite	50 ,,	50 ,,
Sodium carbonate	50 ,,	50 ,,
Potassium bromide	½ grain	½ *part*
Water	2¼ ounces	1000 *parts*

Another formula given by Warnerke is :—

Eikonogen	10 grains	10 *parts*
Caustic potash	10 ,,	10 ,,
Sodium sulphite	20 ,,	20 ,,
Water	¼ ounce	100 ,,

To this is added three to ten times the water, according to the result required. The stronger solution gives a denser negative than the more dilute, and in case of over-exposure potassium bromide (ten per cent. solution) should be added. It should be noted that development can be instantly checked with this developer, as, indeed, it can with any other alkaline one by immersing the plate in a dilute solution (one per cent.) of acetic acid. Citric acid may also be employed, but it is less readily made, and is slightly more expensive.

It is claimed for eikonogen that it will give greater detail with a short exposure than the foregoing alkaline developers. This we demur to. It is believed that whatever developer be used as at present discovered, the detail that is brought out is similar. (We are excluding the very slow developers of some of the iron salts, as they are naturally less energetic in their action.)

Development with pyro-catechin: in the *British Journal Almanac* for 1899 * is the following note :—

"Drs. H. W. Vogel and P. Hanneke report upon a new preparation of pyro-catechin, manufactured by Dr. Ludwig Ellon and Co. This developer has not found much favour hitherto, probably on account of its cost and want of uniformity. The latter was doubtless due to impurities. The new preparation is chemically pure and much cheaper.

"The first workable formula for pyro-catechin was composed as follows :—

SOLUTION I

Water	500 c.c.
Sulphite of soda	20 grammes
Pyro-catechin	10 „

SOLUTION II

Water	500 c.c.
Carbonate of potash	100 grammes

"One part of each to be added to one part of water. The developer is excellent, but rather slow.

"Messrs. Lumière recommended tribasic phosphate of soda as

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* *B. J. Almanac*, 1899, p. 938.

an accelerator to shorten the time of development, and Poulenc Frères gave the following formula :—

SOLUTION I

Water	500 c.c.
Sulphite of soda	50 grammes
Pyro-catechin	10 ,,

SOLUTION II

Water	500 c.c.
Tribasic phosphate of soda ...	100 grammes

One part of each to be added to one part of water.

"Unfortunately the tribasic phosphate of soda is expensive. Messrs. Ellon and Co. have overcome this difficulty by substituting phosphate of soda and caustic soda as follows :—

SOLUTION I

Pyro-catechin	5 grammes
Sulphite of soda	25 ,,
Water	250 c.c.

SOLUTION II

Water	250 c.c.
Phosphate of soda	47 grammes
Caustic soda	5 ,,

For use take one part of each and one part of water.

"Although more rapid in its action, this developer does not fog, and gives negatives of excellent quality. With time exposures it is recommended to use a little bromide. Pyro-catechin has the advantage of being uninfluenced by temperature. It does not stain, and gives brilliant negatives of good colour.

"It may be used for bromide paper with excellent results, according to the following one-solution formula :—

Water	1000 c.c.
Sulphite of soda	25 grammes
Carbonate of soda	50 ,,
Pyro-catechin	10 ,,

Dilute with an equal quantity of water."

“It has been found at the Imperial Technical School, Berlin, that pyro-catechin developer will preserve its energy for more than two years. A concentrated solution may be prepared as follows:—

Water	200	c.c.
Crystallised sulphite of soda ...	25	grammes
Crystallised carbonate of soda ...	50	„
Pyro-catechin	10	„

For use, one part of the solution is diluted with five parts of water.” *

Development with Pyro-acetone.—The use of acetone with pyro- and hydrokinone has been lately introduced by Lumière, who gives the following formulæ:—

PYROGALLIC ACID FORMULA

Pyrogallic acid	1	part
Water	100	„
Sodium sulphite anhyd.	5	„
Acetone solution	10	„

HYDROKINONE FORMULA

Hydrokinone	2	parts
Water	100	„
Sodium sulphite anhyd.	10	„
Acetone solution	10	„

Bromide of potassium should be used with time exposures, and the amount of acetone may be increased for under-timed exposures. The image given is of a good black colour.

Recently a number of other developers have been introduced, which have found favour with many workers.

Development with Metol.†—Metol is sold under two names, Metol-Hauff and Metol-Andresen. It is a grey crystalline powder sparingly soluble in water, and gives negatives blue-black in colour. The formulæ given by the two makers—and they act satisfactorily—are:—

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* *B. J. Almanac*, 1899, p. 939.

† Metol is the sulphate of methyl-para-amido-meta-creosol.

Metol-Hauff

A

Water	100	parts
Metol	1	,,
Sodium sulphite	10	,,

B

Water	100	parts
Carbonate of potash	10	,,
Or substitute carbonate of soda	20	,,

For use take three parts of A to one of B, with the addition of bromide of potassium, as required for full exposures.

The mixed developer contains in each ounce approximately:—

Metol	3	grains
Sodium sulphite	30	,,
Carbonate of potash	10	,,
Bromide of potassium, say	½	,,

Metol-Andresen

A

Water	100	parts
Metol	2	,,
Sulphite of sodium	18	,,

B

Water	100	parts
Carbonate of soda	6	,,

For use, take one part of A to three parts of B, with bromide of potassium as required.

The mixed developer contains in each ounce approximately:—

Metol	2	grains
Sodium sulphite	18	,,
Carbonate of soda	18	,,
Bromide of potassium (say)	½	,,

Mr. R. Child Bayley recommends as a normal developer:—

Metol	2 grains
Sodium carbonate	20 "
Potassium bromide	½ "
Water, up to	1 ounce

with as much sulphite of soda as is practicable.

In mixing solutions, the metol should first be dissolved in warm water, then the sulphite of soda, and if a one-solution developer is being made up the other chemicals are added.

As metol works best in conjunction with large quantities of sulphite, the amounts given in the makers' formula may be increased with good effect. Bromide of potassium is necessary with full exposures, and is desirable in small quantities even with brief exposures.

The image appears almost as soon as the developer is poured on the plate, and if the plate were fixed when judged by the standard of pyrogallic development, an under-developed negative would be the result. The action should be continued until with a correctly-timed exposure development appears to flag, when a quick-printing negative with sufficient density for ordinary subjects will be obtained.

When greater density is required than can be obtained with metol alone, the following combination of metol and hydrokinone may be used:—

A

Metol	11 parts
Sulphite of soda	34 "
Water	1000 "

B

Hydrokinone	11 parts
Citric acid	3 "
Water	1000 "

C

Carbonate of potash	50 parts
Water	1000 "

For use with correct exposures, take one part each of A and B and two parts of C. For over-exposure add a few drops of a ten per cent. solution of bromide of potassium; for slight under-exposure increase C. The normal developer will contain in each ounce approximately :—

Metol	1 grain
Sodium sulphite	4 ,,
Hydrokinone	1 ,,
Citric acid	½ ,,
Carbonate of potash	10 ,,

Metol has an irritating effect on the skin, for which no cure but time and ceasing to use the developer has yet been discovered. As the disease is very painful, the fingers should not be wetted with the developer more than is absolutely necessary, and should be very thoroughly cleansed after development.

*Development with Amidol.**—Amidol is a whitish crystalline powder easily soluble in water. Unlike pyro, it requires no alkali, but is capable of developing a negative even in an acid state. In practice it is desirable to use it in conjunction with a large proportion of sulphite, which acts as the accelerating agent.

As with metol, the image appears soon after the developer is poured on the plate, and to secure density development must be continued for some time after all details have made their appearance. The image is a good black, and prints very quickly. Amidol is much used for developing prints upon bromide paper, for which purpose, as no clearing bath is required, and as it gives good grey and black tones, it is very suitable.

In solution it does not keep in working condition for any length of time, it is therefore desirable to keep for use a solution of sulphite of soda of the required strength and add the dry amidol in quantities sufficient for the work in hand.

A serviceable developer is as follows :—

Amidol	1½ grains
Sodium sulphite	48 ,,
Potassium bromide, from	½ to 1½ ,,

For slightly under-exposed plates the sulphite of soda may

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* Diamido-phenol.

be strengthened by the addition of a saturated solution. For over-exposure the bromide of potassium must be greatly increased, as its restraining powers are not great with this developer.

Development with Glycin.—Glycin is a white crystalline powder which if carelessly kept turns to a brownish-black and loses its developing powers. When fresh it is readily soluble in water.

The image is developed steadily, and gains density as the detail is brought out. It yields negatives of considerable vigour with clear shadows, and is recommended by the makers for line negatives on dry plates.

A stock solution which will keep well is :—

Glycin	1 ounce
Sodium sulphite	8 ounces
Potassium carbonate	5 „
Water, to one pint	20 „

The sulphite is first dissolved in hot water, and the glycin and potassium carbonate added.

For use, one ounce of the stock solution is diluted with four times its bulk of water, the working solution containing in each ounce practically :—

Glycin	4½ grains
Sodium sulphite	13 „
Potassium carbonate	21 „

Bromide of potassium is not absolutely necessary with correctly exposed plates, and with over-exposed plates it should be added cautiously, as even a very small proportion will retard development considerably.

A method of working has been recommended with this developer which may be useful when large numbers of plates exposed in the hand-camera have to be dealt with. The following solution is made up :—

Glycin	40 grains
Sodium sulphite	200 „
Carbonate of potassium	200 „
Bromide of potassium	1 „
Water	40 ounces

A grooved porcelain trough is filled with the solution and the plates inserted in the grooves. As development is very slow, taking hours to complete, it is possible to attend to a large number of plates at once.

Development with Para-amido-phenol or Rodinal.—Rodinal is the commercial form in which para-amido-phenol is sold, and is a fluid containing the developer in a concentrated form with sodium sulphite and a caustic alkali. It is issued in rubber-stoppered bottles, in which it keeps well, slight discolouration not affecting its developing powers. For use it should be diluted with from twenty to thirty times its bulk of water.

The image appears quickly, but gains density slowly; as in the cases of metol and amidol, the image is blue-black with little light stopping power. Bromide does not restrain so powerfully as with glycin, and may be freely used.

Development with Diphenol.—Diphenol is sold in bottles of a brown solution ready for use. The instructions given are to take for correct exposure—Diphenol one part, water fifteen to twenty parts. For under-exposure—Diphenol one part, water twenty to twenty-five parts. For over-exposure—Diphenol one part, water eight to ten parts.

Although bromide is not recommended in the instructions, a few drops of a ten per cent. solution to the ounce of developer is advisable. The developer loses power slightly in a few weeks after the bottle has been opened. The image appears steadily, and density is easily obtained. The silver is deposited of a good black colour.

*Development with Ortol.**—Ortol was introduced by Dr. Hauff in 1897. It is a yellowish-white crystalline powder, readily soluble in water with a strongly acid reaction, and produces a colourless solution. Ortol has no developing action by itself. Combined with sulphite it will develop very slowly; with the addition of carbonate of sodium development takes place rapidly and steadily, yielding a black image.

The original formula as issued by Dr. Hauff is:—

A

Ortol	15 parts
Metabisulphite	7 ,,
Water	1000 ,,

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* Ortho-methyl-amidol-phenol.

B

Sodium carbonate	100 parts
Sodium sulphite	125 „
Water	1000 „

A and B to be mixed in equal quantities, and one grain of potassium bromide added to each ounce of mixed developer.

Mr. Bothamley recommends that the quantity of sulphite should be reduced to 50 parts, and the bromide added to B solution to the amount of 2½ parts, in which case the developer acts a little more speedily, but without any other marked difference.

The amended formula contains in each ounce approximately:—

Ortol	3½ grains
Potassium metabisulphite ...	2 „
Sodium carbonate	25 „
Potassium bromide	½ „
Sodium sulphite	12 „

Dr. Hauff originally suggested the addition of a small quantity of hypo-sulphite to the developer, and Dr. Eder supported the recommendation, but Mr. Bothamley found that the addition of hypo produced fog without any compensating advantage. For rapid plates and for over-exposure the bromide should be increased.

Development with Adurol.—Adurol is amongst the latest developers introduced, and has been reported upon by Mr. Bothamley to the following effect:—"It is a white, semi-crystalline powder which dissolves fairly easily in water, and more readily in solutions of sodium sulphite and potassium metabisulphite. It remains in a good condition both in the dry state and in solution when tested under trying conditions that would not occur in practical work. It develops rapidly and steadily, yielding negatives of excellent vigour and gradation and of a good black colour. There is little tendency to produce fog except with very rapid plates, and that tendency is readily checked by the addition of a small quantity of potassium bromide, which has a strong restraining effect and keeps development under control, even with plates which have been considerably over-exposed. Half a grain per ounce of bromide exerts a marked effect, and one grain to the ounce slows development considerably.

"It combines the cleanliness and vigour in the negative characteristic of hydrokinone, with a rapidity of action equal to pyrogallic acid. It is a developer of considerable value for general work, and promises well as a developer for line subjects. The two following formulæ are recommended by the maker :—

CONCENTRATED ONE-SOLUTION

Water	400 parts
Sodium sulphite	75 „
Potassium carbonate	150 „
Adurol	15 „

For use dilute with from five to seven times its volume of water.

SEPARATE SOLUTIONS

A

Water	500 parts
Sodium sulphite	50 „
Adurol	10 „

B

Water	500 parts
Potassium carbonate	50 „

For use mix equal volumes."

A developer for normal subjects would contain in each ounce—

Adurol	4 grains
Sodium sulphite	20 „
Potassium carbonate	24 „
Potassium bromide	¼ „

Since writing the above yet another developer has been brought out under the name of Kachin. The maker's formulæ are :—

SINGLE SOLUTION

Water	200 c.c.
Sulphite of soda	5 grammes
Carbonate of soda (crystals) ...	10 „
Kachin	2 „

TWO-SOLUTION (1)

Water	250 c.c.
Sulphite of soda	25 grammes
Kachin	5 ,,

(2)

Water	250 c.c.
Caustic soda	5 grammes
Phosphate of soda	47 ,,

For use take one part of No. 1, one part of No. 2, and one part of water.

No bromide is required with correct exposures. For over-exposure ½ grain to 1 grain of potassium bromide may be added to the ounce of developer.

It appears probable that the large proportions of sodium sulphite in the above formulæ might be greatly reduced if a little citric acid were used with it.

The developer does not stain the negative fingers or nails, and the image is of a good black colour, slightly broken with brown.

The following tables of developers for negative work recommended by the plate-makers, showing grains per ounce, were compiled by R. Child Bayley for the *Photographic News*.

PYRO-AMMONIA DEVELOPERS FOR NEGATIVE WORK.

Name of Plate-maker giving Formula.	Pyrogallol.	Potassium Bromide.	Ammonium Bromide.	Sodium Sulphite.	Potassium Meta-bisulphite.	Liquor Ammonia ·880.
Cadett & Neall	1·2	...	·6	...	1·25	*3·75
Cadett & Neall (alternative formula)	1·2	...	1·2	...	...	*3·75
B. J. Edwards & Co.	1·2	·3	...	...	...	1·2
B. J. Edwards & Co. (Redeveloper)	8	...	24	...	...	16
Elliott & Son (Barnet Ordinary plate)	1	...	2	...	...	4·5
Elliott & Son (for studio use)	1	...	2	...	...	4
Elliott & Son (for outdoor use)	2	...	3	...	...	4
Marion & Co.	2·4	...	2·4	...	...	4·8
Mawson & Swan (Mawson and Castle plates)	1·5	...	·75	...	1·5	3·5
Mawson & Swan (for Photo-mechanical plates)	1·5	...	1·5	...	1·5	3·5
Paget Prize Plate Co.	2	...	·33	5	...	2
Paget Prize Plate Co. (Phœnix plate)	2	...	·5	5	...	2
Thomas & Co.	2	1	...	...	...	1
Mean of the above (omitting the Re-developer)	1·5	...	1·4	...	...	8

* The ammonia in these formulæ is described as having a specific gravity of ·890.

NOTE.—The pyrogallol solution in all the above is a distinctly acid one; hence the figures for liquor ammonia are a little in excess of the amount actually present, but the difference is not an appreciable one

PYRO-SODA DEVELOPER FOR NEGATIVE WORK.

Name of Plate-maker giving Formula.	Pyrogallol.	Potassium Bromide.	Sodium Sulphite.	Potassium Meta-bisulphite.	Sodium Meta-bisulphite.	Crystallised Sodium Carbonate.
Austin Edwards	3	...	30	...	...	27
Cadett & Neall	3	...	41	·3	...	30
B. J. Edwards & Co.	3	·9	30	...	...	24
B. J. Edwards & Co. (alternative formula)	3	...	12	...	3	36
B. J. Edwards & Co. (Redeveloper)	8	16	...	...	8	72
Elliott & Son (Barnett Ordinary plate)	1·3	·1 to ·2	13	...	...	11·7
Ilford Co. (for soft negatives)	2	·5	24	...	...	24
Ilford Co. (for dense negatives)	4	·5	24	...	...	24
Imperial Dry Plate Co.	4	·4	24	·325	...	24
Marion & Co.	3	·375	24	...	...	24
Mawson & Swan (Mawson and Castle plates)	3	...	40	·75	...	30
Paget Prize Plate Co.	3	...	24	...	...	24
Thomas & Co.	3	·75	12	...	...	18
Mean of the above (omitting the Redeveloper)	3	·3	24	...	...	24

HYDROQUINONE DEVELOPERS FOR NEGATIVE WORK.

Name of Maker giving the Formula.	Hydroquinone.	Potassium Bromide.	Sodium Sulphite.	Potassium Meta-bisulp.	Potassium Carbonate.	Potassium Hydrate.	Sodium Hydrate.	Sodium Carbonate.
Austin Edwards	3	·75	24	...	48	...	...	...
B. J. Edwards & Co.	5	·3	4	...	10	...	...	...
B. J. Edwards & Co. (*Redeveloper*)	5	5	80	...	...	...	...	40
Ilford Co. (Universal developer for plates)	4	·75	22	...	...	...	2·5	...
Imperial Dry Plate Co.	3·75	1·25	24	25	...	...	2·5	...
Marion & Co.	2	·25	6	...	...	4	...	...
Marion & Co.	2	...	12	...	...	...	...	16
Mawson & Swan (Mawson and Castle plates)	2	·25	...	2	...	4	...	...
Mawson & Swan (Photo-mechanical plates)	2	·5	...	2	...	4	...	...
Paget Prize Plate Co.	4	·1	20	...	...	...	4	...
Thomas & Co.	2	·5	12	...	...	...	2	...
Mean of the above (omitting the Redeveloper)	3	·5	15	...	...	4	...	...

EIKONOGEN DEVELOPERS FOR NEGATIVE WORK.

Name of Maker giving the Formula.	Eikonogen.	Potassium Bromide.	Sulphite Sodium.	Potassium Carbonate.	Sodium Carbonate.
B. J. Edwards & Co.	11·4	...	46	23	...
Marion & Co. (for portraits and landscapes)	6	...	24	...	18
Marion & Co. (for instantaneous work)	6	...	24	18	...
Marion & Co. (for the *very shortest* exposures)	16	...	80	32	...
Mawson & Swan (Mawson and Castle plates)	7·5	...	20	30	...
Paget Prize Plate Co.	6	·2	18	12	...
Mean of the above	9	...	35	23	...

METOL DEVELOPERS FOR NEGATIVE WORK.

Name of Maker giving the Formula.	Metol.	Potassium Bromide.	Sodium Sulphite.	Potassium Meta-bisulphite.	Sodium Carbonate.	Potassium Carbonate.
Imperial Dry Plate Co.	2·5	·5	24	·25	24	...
Thomas & Co.	2·5	1	24	...	12	9
Mean of the above	2·5	·75	24	...	18	...

MIXED DEVELOPERS FOR NEGATIVE WORK.

Name of Maker giving the Formula.	Pyrogallol.	Metol.	Hydroquinone.	Potassium Bromide.	Sodium Sulphite.	Potassium Meta-bisulp.	Sodium Carbonate.	Potassium Hydrate.
Imperial Dry Plate Co. (*Standard* developer)	1·375	1·125	...	·5	...	3	48	...
,, ,, ,, (*Universal* ,,)	...	1	1·25	·375	3	...	...	4·5
,, ,, ,, (*Single Solution* ,,)	...	2·5	2	1·25	25	...	25	...

CHAPTER XVII

FERROUS OXALATE DEVELOPER—THE ALUM AND FIXING BATHS

WE next come to the second great branch of developers for dry plates, viz. the ferrous oxalate. At page 21 we have already given the reaction that takes place when silver bromide is reduced by it, and we need not dwell on that again here. Ferrous oxalate is itself a lemon-coloured powder, almost insoluble in water, but dissolving in a solution of neutral potassium oxalate; but it may be formed by mixing a solution of ferrous sulphate (sulphate of iron) with a solution of potassium oxalate. The oxalate of iron in powder is somewhat expensive, so that usually the solution is formed by mixing the cheap sulphate with the oxalate of the alkali. The formation of the oxalate developer with the powder will first be given, as it certainly is the strongest form.

Preparation of the Developer with the Oxalate of Iron.—A saturated solution of the neutral potassium oxalate is first prepared, preferably by boiling it in water, a portion undissolved remaining behind. A crystal of oxalic acid is next added to prevent any trace of alkalinity. At one time we used to add ferrous oxalate to warm potassium oxalate solution, only so much of the oxalate being added as to leave a slight portion of the ferrous compound undissolved. We prefer now to add the ferrous oxalate to the cold saturated solution of the potassium salt, and to allow them to remain in contact with one another for twenty-four hours, shaking occasionally. The clear solution can be decanted off. This method prevents the deposition of crystals on the sides of the bottles, which always are deposited if the ferrous oxalate be heated with the potassium oxalate. The solution will be of a deep red colour.

The ferrous oxalate solution rapidly oxidises by contact with the air, as already hinted at, and our own practice is to fill 4-ounce bottles with it, cork them up, and then to lute the corks with solid paraffin. Mr. Warnerke adopts the following plan. He uses a large stoppered bottle having an opening near the bottom, such as can be procured at any chemical dealer's. Into this opening he fits a cork carrying a small glass tube; on to the end of this (outside the bottle, of course) he fits a piece of india-rubber tubing, and connects this with a similar piece of bent glass tubing, which reaches nearly as high as the top of the bottle. He fills the bottle two-thirds the way up with the ferrous oxalate solution, and then pours in a layer of liquid paraffin. This prevents any access of air to the solution. To get at the solution, the bent tube is turned down below the level of the paraffin, and the developing cup or bottle filled.

Dr. Eder's Ferrous Oxalate.—Mr. York, working on the directions of Dr. Eder, gives the following formula:—

No. 1.

Ferrous sulphate	60 grains ...	60 *parts*
Water	1 ounce ...	440 „

No. 2.

Potassium oxalate (neutral) ...	1 ounce ...	440 *parts*
Water	3 ounces ...	1,320 „

This makes up four ounces of developer, and by using these quantities saturated solutions are obtained. Personally, we prefer four parts of No. 2 to one of No. 1.

Strong Ferrous Oxalate Developer Prepared with Ferrous Sulphate.—A still stronger form of ferrous oxalate developer can be made by taking a saturated solution of potassium oxalate and adding to it *solid* ferrous sulphate. This must be added cautiously, since part of the potassium oxalate is converted into ferrous oxalate, and the remainder holds it in solution.

Mr. York's formula for the potassium oxalate may be taken, and to it 200 grains (200 *parts*) of ferrous sulphate of iron be added (powdered up in a mortar by preference). It will probably be found that some of the yellow oxalate will precipitate, in which case *crystals* of potassium oxalate must be added to the solution till such precipitate is re-dissolved.

Developing with Ferrous Oxalate.—There are various ways of using this developer, and much should depend on the exposure given and the kind of plate employed. If the plate has a glossy surface, and has been prepared with hard gelatine, we recommend that it be soaked for five minutes in ordinary water, in order to cause the gelatine to expand vertically, and so to soften the film, after which time the water is poured off. If the surface be matt, we recommend that tho plate be not wetted. Two developing solutions are prepared. A saturated solution of ferrous oxalate in potassium oxalate is prepared as given at page 179, and sufficient of it necessary to develop all the plates, which it may be desired to do, is diluted with an equal bulk of water,* and when the slight precipitation of ferrous oxalate has taken place, sufficient of the dilute solution to well cover the plate is poured over its surface and watched for half-a-minute. If the image appears to be developing fairly well, and detail coming out, this developer is continued till all detail appears, when it is poured back into a developing cup, and density obtained with fresh undiluted solution of ferrous oxalate, to each ounce of which 10 drops of a 2 per cent. solution of potassium bromide are added. This gives density. The development should be continued till the image appears well on the surface of the gelatine next the glass plate, supposing the film to be of medium thickness.

Instead of the image coming out properly with the developer, as indicated above, we will suppose that after half-a-minute the high-lights only slightly appear. In this case, to each ounce of developer 20 drops of a solution of sodium hyposulphite made as follows are dropped into the cup, and the dilute developer poured on to the hyposulphite :—

Sodium hyposulphite ...	20 grains ...	2 *parts*
Water	1 ounce ...	44 ,,

The mixture is once more poured on the plate, and if not

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* Perhaps the best plan is, when the concentrated solution, as prepared at page 179, is made, to dilute it with an equal bulk of water before filtering. Some ferrous oxalate will be thrown down, and, of course, can be utilised afterwards.

much under-exposed for the normal developer, the details should appear rapidly and with good gradation. When all detail is out the plate is washed, and the strong ferrous oxalate solution, with the bromide, applied as before, to secure density.

Supposing the plate to be over-exposed when the first developing solution is applied, the details will begin to appear too rapidly. It should be immediately poured off, and the plate flooded with a solution of potassium bromide (5 grains to the ounce of water, 1 per cent.), which should be allowed to soak into the film for a couple of minutes. It is then drained off. To each ounce (100 *parts*) of the weak solution 20 drops (4 *parts*) of the same solution may be added, and the developer applied again. This should allow the image to come up properly without flatness, but it may be desirable to finish with the strong solution as before.

Some photographers like to use old ferrous oxalate solutions, to which sodium hyposulphite is added at the commencement. This, no doubt, gives brilliant pictures, but is apt to cause the necessary exposure to be prolonged. On the whole, we recommend tolerably fresh ferrous oxalate if the greatest benefit is to be obtained from the developer.

There are some plates which are unsuited for ferrous oxalate development. They are generally those which are prepared with soft gelatine in hot weather. The film shows reticulation, and the image appears granular. In that case resort should be had to alkaline development, by which this evil will be mitigated.

The Alum Bath.—After development, by any method, the plate should be placed in a saturated solution of potash alum or of chrome alum, which is conveniently held in a dipping bath or flat dish. The plate is first rinsed under the tap. This bath prevents frilling; but in the case of ferrous oxalate development it does more—it decomposes any calcium oxalate which may be formed by the water (containing lime) with which the developer is washed off. After a couple of minutes' immersion in this bath, it is washed under the tap, using a gentle stream of water, when it is ready for the fixing bath.

Fixing the Negatives.—To fix the negative by any process, a solution of hyposulphite of soda should be used. One pound

(16 *parts*) of hyposulphite should be dissolved in 1 quart (40 *parts*) of water. This strength is, perhaps, rather great for some commercial plates, and it might be made up to about 2 ounces of hyposulphite to a half-pint of water—say a 20 per cent. solution. This reduces the chance of frilling. The use of cyanide is said to be inadmissible, as it attacks the image.* The plate is known to be fixed by looking at the back of it, which should appear black, without any shade of green about it. The fixing should take place in the dark-room, as a rule, though if the plate be alumed it will not suffer; if it has not been alumed it will veil, and with an alkaline developer will often show green fog.

After fixing the negative, it has to be thoroughly washed. There are various contrivances for effecting this. The rack shown at page 52 is a good contrivance, as it can be immersed in a pail of water, and a dozen negatives can be washed at one time. The heavier saline solution sinks to the bottom of the water with which the trough is filled, and comparatively pure water is in contact with the negative. Where only a few negatives are to be washed, flat dishes answer, about four changes of water being given, each change being made at the end of every half-hour. To ensure thorough elimination of the hyposulphite, the plate may be subsequently immersed in the alum bath, and again washed. It must be recollected that thorough washing of any film depends on its thickness, and we may say that, as a rule, we consider six hours not too long washing for a thick film. When the plate is considered washed, it may be placed in a rack and allowed to dry spontaneously. The plan of standing plates upon blotting-paper is sometimes resorted to. This is often a mistake, unless it stands on a corner. Any dust collected on the paper mounts up the plate by capillary attraction and dries on the plate. If rapid drying be required, it may be flooded three times with methylated spirits, or immersed in a dish of spirit for five minutes, when it will dry very readily, and the drying can even be accelerated by a gentle heat.

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* A dilute solution can, however, be used.

CHAPTER XVIII

INTENSIFYING AND VARNISHING GELATINE NEGATIVES

Silver Intensification.—This part of the gelatino-bromide process is one which has to be carried out with the very greatest care, since all methods of giving intensity have yet to stand the test of time. Now, as a rule, a gelatine negative has to be intensified *after* fixing, since the opacity of the film is usually so great that the operator is unaware what density his negative has taken under development. The great desideratum is a good silver intensifier, but this is fraught with so many dangers that great precautions must be taken to ensure success. It may be laid down as an axiom that, to be successful, the whole of the hyposulphite of soda and silver must be eliminated from the film, and where the film is of any thickness, this is by no means a matter of taking a short time. The writer finds after the green tint of the unacted-upon salt has disappeared in fixing, the plate should be placed in fresh hyposulphite, and kept there for a short time. This being done, the plate had better be kept in water for an hour or more, the water being changed at intervals. After this, the gelatine film may be made more secure by applying to it a solution of *peroxide of hydrogen* in water. A drachm (55 *parts*) of what is called a 20-volume solution to 5 ounces (2200 *parts*) of water is sufficient. When it has soaked in this for half-an-hour it is again washed, and intensification can commence. Another plan is, after thorough washing, to immerse the plate in fresh alum solution for half-an-hour, again washing thoroughly, and allow it to dry. Intensification may then be proceeded with. Those who may have endeavoured to intensify with pyrogallic acid and silver, as described in the wet process, a negative treated in the ordinary way, will find that red stains occur almost invariably where the film is thickest—that is, where the hyposulphites have not been thoroughly eliminated; and to eliminate them this extra precaution above indicated is necessary. The formula for the iron intensifier given for the wet process is recommended if intensification by this method is to be tried. Cyanide will generally remove any red stain which may occur if the above hyposulphite destroying solutions have been applied first.

It by no means follows that a film thus intensified would be free from a liability to change in the presence of light, since the silver might partially combine with the gelatine. After density has been attained, the plate is washed and put in a dish containing common salt, and once more passed into the fixing bath for a few seconds, again washed, and then dried. After many years' trial the writer has, however, most unwillingly come to the conclusion that a valuable negative should not be intensified by the deposition of metallic silver as described.

Another silver intensifier due to Mr. J. B. B. Wellington has been found to work well. The following solutions are made:—

SOLUTION A

Silver Nitrate ...	120 grains ...	120 *parts*
Water distilled ...	2 ounces ...	880 ,,

SOLUTION B

Ammonium Sulphocyanide ...	240 grains ...	240 *parts*
Water	3 ounces ...	1320 ,,

Solution B is added to A, and kept in the dark. For use the bottle is shaken, and sufficient of the liquid and precipitate taken for the plate to be intensified. A strong solution of hyposulphite of soda is slowly added till all but a trace of the precipitate is dissolved. To each ounce of this solution 3 grains of pyro from the 10 per cent. stock solution preserved with sodium sulphite, and 4 minims of strong ammonia are added and poured upon the plate. Should intensification not take place in a few minutes a little more ammonia should be cautiously added. An excess of ammonia will cause the whole of the silver to be precipitated. It is advisable to protect the edges of the plate with waterproof varnish and to avoid touching the surface of the negative during intensification, as the sulphocyanide of ammonia has a tendency to frill and blister the gelatine film.

With fresh plates the process gives satisfactory results; with stale plates, and with those which have been forced in development the intensifier has a tendency to cause iridescent silver stains.

Mercury Intensifiers.—The next intensifiers are the mercury intensifiers, some of which may be classed as the most uncertain in their action and in the permanency of their results. The negative can be intensified either immediately after the washing which follows the fixing, or it can be employed upon a negative which has been dried. In the latter case the negative must be steeped for a minute or two in water. Mr. England recommended the following as giving him what he desires:—

Mercuric chloride (bichloride of mercury)	20 grains	20 *parts*
Ammonium chloride ...	20 „	20 „
Water	1 ounce	440 „

After the negative has been thoroughly washed, the above solution is poured over it till the surface assumes a grey tint. After a thorough wash, a weak solution of ammonia (10 drops to 1 ounce of water) is applied till a dark tone is assumed by a reflected light, and brown by transmitted light. With collodion the intensity thus given is unstable, and the film has a tendency to bleach.

The next intensifier is one in which we have the greatest faith, as it gives the negative a beautiful black colour. Two solutions are made as follows:—

No. 1.—	Mercuric chloride (bichloride of mercury)	100 grains ...	10 *parts*
	Bromide of potassium ...	100 „ ...	10 „
	Water	10 ounces ...	440 „
No. 2.—	Nitrate of silver	100 grains ...	10 „
	Water	10 ounces ...	440 „

To No. 2 is added cyanide of potassium, but not sufficient to dissolve the last trace of the precipitate which is formed on the first addition of the cyanide. It is convenient to make up a 100-grain solution of cyanide of potassium (which, be it remembered, is a deadly poison, and should be handled with caution) to 1 ounce of water (20 per cent.), and to add this to the silver nitrate solution till the desired end is attained. The plate, after being dried, is soaked in water for a couple of minutes, and then immersed in a dish containing No. 1. After a few minutes the image will be found thoroughly bleached, when it is taken out and washed for a quarter of an hour. It is then placed in a dish of No. 2 till the bleaching at the back of the plate gives place to a blackening; it is then taken out and washed thoroughly. It does not do to leave the plate too long in No. 2, as it is apt to reduce the intensity after a certain point is reached. Should the negative be now too dense, the density may be gradually and evenly reduced by immersing it in a weak solution (20 grains to the ounce of water, or 4 per cent.) of hyposulphite of soda. This will take away all the acquired density if the immersion is prolonged. The negative, after this method of intensification, looks denser when wet than when dry; allowance must be made for this. With this intensifier, we have means at command to alter the relative gradations in a negative in a very simple manner. If, after washing is complete, a camel's-hair brush be charged with the solution of hyposulphite, parts may be totally reduced very evenly, and the results may be watched, and those parts which are too intense modified. In some instances we adopt the contrary method, and apply the mercury solution with the brush. After the plate is wetted, a water-colour brush may be charged with the solution, and bleaching induced where greater density is required.

Another favourite method of intensification when considerable increase of density is required is to bleach the negative in a saturated solution of mercuric chloride in water rendered very slightly acid with hydrochloric acid, and then develop with ferrous oxalate or metol developers. This reduces both the mercurous chloride and the silver chloride to the mercury and silver. This process may be repeated again and again until, from a mere shadow of a picture, a printable negative is obtained. In this process, care should be taken *at every stage* *that the washing is complete.* The negatives should be washed in rain or distilled water immediately before and after the application of the ferrous oxalate. This prevents the formation of oxalate of lime from the hard water, and a consequent muddiness.

The Platinotype Company uses an intensifier which is composed of mercuric chloride and a salt of platinum. The intensifying action of this liquid is gradual and effective, and the negative seems to be unaltered by time, which is more than can be said when some forms of mercury intensifiers are used.

Uranium Intensifier.—Dr. Eder, in his *Modern Dry Plates*, has recommended an uranium intensifier, which is made as follows:—

Uranium nitrate	15 grains ...	15 *parts*
Potassium ferricyanide	15 ,, ...	15 ,,
Water	4 ounces ...	1,760 ,,

Before using this, the plate must be thoroughly washed, as traces of hyposulphite cause a reduction of the uranic salt, and a consequent slight chocolate-coloured veil over the shadows. The plate is immersed in the solution, and the details in the shadows are first attacked, and then the half-tones, and finally the high-lights. This intensification is permanent, and can be used with much advantage. Dr. Eder says that if a negative will not acquire sufficient intensity with uranium, it may be laid aside as useless, and with this we agree. It is desirable that negatives intensified with uranium should be washed in distilled or soft water. Prolonged washing in hard water will remove the uranium deposit. If it is desirable to undo the intensification, the negative should be bathed in a weak solution of carbonate of ammonia.

A varnished negative may be intensified after removing the varnish. This is effected by soaking it in warm methylated spirit, and, after rinsing under the tap, applying a tuft of cotton-wool to the surface. If it be collodionised, the collodion can be removed by applying one part of ether and two parts of alcohol by flooding in a dish.

Intensification, or Development of the Latent Image after Fixation.

Recently many experiments have been made in the direction of developing gelatine plates after fixation. To ensure success the plate must receive many times (twenty to thirty times) the normal exposure. It must be fixed in a fresh bath of hyposulphite of soda in the dark and be thoroughly washed.

The Wellington silver intensifier compounded as on page 184 is applied to the plate. Great density with clear shadows can be obtained, though it may be necessary to use two or more freshly-prepared developers. For line work upon gelatine plates, when it is inconvenient to use wet collodion, the method may be recommended, as also for making lantern slides.

The precautions to avoid frilling and blistering recommended with developed plates should be employed with this process. A modification of this process, in which metol without an alkaline carbonate was substituted for pyro-ammonia, was tested by the editor of *Photography*, who found that when the silver intensifier as above was added to the metol, good results were obtained.

The formula adopted was as follows :—

Metol	120	grains
Sodium sulphite	2½	ounces
Water	20	„

To each ounce of this an ounce of the silver intensifier was added, when, after an hour or two of development, a creamy white image was obtained, farther development strengthened the image, and finally intensification with mercury gave a satisfactory negative.

Farther experiments showed that no frilling took place, no stains were produced, and no precipitation of silver occurred except where required on the image.

Varnishing Gelatine Negatives.—When the plate is dried after intensification or fixing, it is varnished; this is done to protect the film from the free silver nitrate in silver printing. The writer for some reasons prefers to give it a preliminary coating of plain collodion. If it has received one to avoid frilling (see page 203), it will be unnecessary to give it another. When the collodion is used, the writer's experience tells him that almost any varnish will answer. Enamel collodion is, perhaps, the best to employ; or it may be made by dissolving six grains of tough pyroxyline in a half-ounce of ether and a half-ounce of alcohol, ·820 (6 *parts* of cotton in 220 *parts* of ether, and 220 *parts* of alcohol). The collodion is poured in a pool at the upper end of the dried plate, and flowed first to the right-hand top corner, next to the left-hand top corner, third to the left-hand bottom corner, and finally, as much as possible is drained off in the bottle at the bottom right-hand corner, giving the plate a gentle rocking motion in order to cause all lines to coalesce. The plate is then set up and allowed to dry. For a varnish, Mr. England used seed-lac in methylated spirit (a saturated solution, and then thinned down until it is of a proper consistency). Any varnish applicable to wet plates is likewise adapted to gelatine plates. To apply the varnish, the plate should be gently warmed over a spirit-lamp or before the fire to such a heat that the back of the hand can only just bear the touch of the plate. The varnish is applied like the collodion. After draining off all excess, and rocking the plate, it is warmed till all spirit has evaporated, and till the film is glossy. A lack of warmth will cause the film to dry "dead." Where many prints are not to be taken, it is believed that the film of collodion alone is sufficient protection against the silver nitrate of the paper combining with the gelatine, and so causing a discolouration. If a negative does get discoloured through this, a very dilute solution of potassium cyanide will usually clear away any marking that may have been made. But great care must be taken in using this solvent of the silver compound, as it attacks metallic silver when in such a state of fine division as that in which it is to be found in the gelatine plate.

An excellent varnish is prepared by dissolving old celloidin films in a solution of acetate of amyl or in acetone. The celloidin is slowly soluble in this menstruum, and should be allowed to settle. The plate is coated with this as with collodion, and when dry (which takes some time to accomplish) it is waterproof. This is an excellent varnish.

It is tough, waterproof, and does not become tacky by heat. It preserves the negative from silver stains, as these may be washed from the varnished surface without injury to the photographic image.

CHAPTER XIX

GELATINO-CHLORIDE

Gelatino-Chloride.—For some purposes a chloride emulsion in gelatine is useful. The method of procedure is precisely that given in Chapter XI., using the boiling process (see page 118). Instead of the formula given (the same page), the following is employed :—

I.—	Sodium chloride	80	grains	80	*parts*
	Nelson's No. 1 gelatine	30	„	30	„
	Hydrochloric acid	5	minims	5	„
	Water	1½	ounces	660	„
II.—	Silver nitrate	200	grains	200	„
	Water	½	ounce	220	„
III.—	Nelson's No. 1 gelatine	30	grains	30	„
	Water	1	ounce	440	„

The above are made into solutions, and in the dark-room. II. and III. are mixed at a temperature of about 100° F., and then I. added, as described in Chapter XI. The emulsion may be boiled for a quarter of an hour, or left unboiled. In either case, 240 grains (240 *parts*) of autotype gelatine, or a similar total quantity of equal parts of hard and soft gelatine dissolved in two ounces (880 *parts*) of water, are added. After setting, the emulsion is washed, and plates coated as described in Chapter XI.

The plates made from unboiled emulsion are very transparent, and of a light orange colour by transmitted light, whilst those made from the boiled emulsion are blue and sap-green.

Though extremely sensitive to daylight, they are much less so to gaslight, as the latter light contains proportionally much less violet than yellow and red in its composition (see page 46); so that more artificial light may be used during development than with bromide plates. This will be found to be of great advantage, as the plates may be examined from time to time within a reasonable distance of a gas flame, and the density thus regulated to a great nicety.

The exposure of the plates to diffused daylight (made with unboiled emulsion) will vary from one to five seconds, and the plates prepared with the boiled emulsion for from a quarter to two seconds, according to the density of the negative; whilst to an ordinary fish-tail gas-burner or paraffin lamp at twelve inches distance the former will require from five to twenty minutes' exposure, and the latter from half-a-minute to three minutes. Mr. A. Cowan states that a very reliable method of exposing when a number of pictures are required exactly alike—or when it is necessary to work at night—is to burn one inch of magnesium ribbon at from nine to twenty-four inches from the negative, according to its density.

Development is effected by the ferrous citrate or ferrous citro-oxalate developer, or by hydrokinone (see page 163) diluted to quarter strength, to which a few drops of a saturated solution of sodium chloride are added. It may also be effected by the ordinary alkaline developers, or by ferrous oxalate if the plate be first treated with a ten per cent. solution of potassium bromide. The bromide converts the chloride into bromide of silver, and probably the minute quantity of sub-chloride into sub-bromide, and consequently the plate is in the same state as an ordinary bromide plate.

Ferrous-Citrate Developer.—The following is the method of making ferrous citrate developer according to Dr. Eder and Capt. Pizzighelli's plan:—600 grains (600 *parts*) of citric acid are dissolved in 4½ ounces (2000 *parts*) of water, with the aid of heat, and exactly neutralised with ammonia; 400 grains (400 *parts*) of citric acid are then added, and the bulk of the fluid made up to 9 ounces (4000 *parts*) of water; 3 drachms (165 *parts*) of this solution are mixed with 1 drachm (55 *parts*) of a saturated solution of ferrous sulphate and 12 minims (12 *parts*) of a solution of sodium chloride (of 16 grains to the ounce of water, 16 *parts* to 440 *parts*).

Ferrous citrate may be purchased and dissolved in a saturated solution of ammonium citrate, adding citric acid if required to give a clear picture.

Ferrous-Citro-Oxalate.—This developer, originally introduced by the writer, is made as follows :—

* Potassium citrate (neutral)	100 grains	100 *parts*
Ferrous oxalate	22 „	22 „
Water	1 ounce	440 „

The potassium citrate is first dissolved in a flask by heat, and, when nearly boiling, the ferrous oxalate is added, and shaken up in it, a cork being used to prevent the access of air to it. This quantity of ferrous oxalate should just dissolve. It may be cooled by allowing cold water to flow over it, and should then have a citrony-red colour.

It may also be made in the cold by the following solution :—

No. 1.—	Potassium citrate	700 grains	70 *parts*
	Potassium oxalate	200 „	20 „
	Water	3½ ounces	154 „
No. 2.—	Ferrous sulphate	300 grains	30 „
	Water	3½ ounces	154 „

These two solutions are mixed in equal proportions.

A weaker solution is made in the same way with the following formula :—

Potassium citrate	50 grains	50 *parts*
Ferrous oxalate	12 „	12 „
Water	1 ounce	440 „

These solutions keep well when corked up in bottles. There is no deposit from keeping, even when oxidised, which is shown by the solution turning an olive-green colour. Any plates may be developed with the ferrous citrate, or ferrous citro-oxalate, without the addition of any restrainer, such as potassium bromide.

The development is carried out in a dish, which is kept rocking. An unboiled emulsion gives a warmer tone than a boiled one.

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* Potassium citrate can be obtained at any druggist's, as it is employed in medicines.

Mr. A. Cowan has made a large number of experiments with chloride emulsion, and by a modification in development has been able to produce images which, by transmitted light, give any colour from warm tones to black.

No. 1, for Cold Tones.

Potassium citrate...	136 grains	136 *parts*
Potassium oxalate	44 „	44 „
Hot distilled water	1 ounce	440 „

No. 2, for Warm Tones.

Citric acid	120 grains	120 *parts*
Ammon. carb.	88 „	88 „
Cold distilled water	1 ounce	440 „

No. 3, for Extra Warm Tones.

Citric acid...	180 grains	180 *parts*
Ammon. carb.	60 „	60 „
Cold distilled water	1 ounce	440 „

To 3 parts of either of these add 1 part of the following at the time of using:—

Ferrous sulphate	140 grains	140 *parts*
Sulphuric acid	1 drop	1 *part*
Water	1 ounce	440 *parts*

The time required for development will vary from one to ten minutes, according to the developer used and the density required. No. 1 is the quickest, No. 3 the slowest developer.

A great variety of tones may be obtained by mixing the first and last developers together in different proportions, and altering the exposure to suit the developer.

The addition of from 5 to 10 minims (5 to 10 *parts*) of a ten per cent. solution of sodium chloride to each ounce (440 *parts*) of developer considerably modifies the colour, and allows of a much longer exposure. It is valuable when very rich, warm tones are required.

Still further difference in colours may be obtained by mixing one of the following with any of the preceding. The first three are, however, what Mr. Cowan recommends:—

No. 4.

Magnesium carbonate	76 grains	... 76 *parts*
Citric acid	120 ,,	... 120 ,,
Water	1 ounce	... 440 ,,

No. 5.

Sodium carbonate (common) ...	205 grains	... 205 *parts*
Citric acid	120 ,,	... 120 ,,
Water	1 ,,	... 440 ,,

To 3 parts of these 1 part of the sulphate of iron solution is added, as with Nos. 1, 2, and 3.

After development the plates are washed and fixed in clean hyposulphite of the usual strength, and are then finally washed as usual.

Plates prepared with the chloride emulsion, if kept exposed to the air, are apt to tarnish, and then develop badly. They should be carefully wrapped in paper, and sealed up in tinfoil.

Transparencies may be taken in the camera, or by contact with these gelatino-chloride plates. The plates prepared with the boiled emulsion are sufficiently rapid for ordinary landscape work, though they possess, if anything, less advantages for it than the ordinary bromide or bromo-iodide plates.

CHAPTER XX

GELATINO-BROMIDE PAPER AND FILMS

Gelatine Bromide Negative Papers.—In the market there are so many excellent brands of bromide paper for use with development, that it seems almost superfluous to give an account of its preparation on a small scale for the amateur, but there may be times when such preparation is necessary, and we accordingly give methods which have succeeded with us. It may be noted that such paper as the Kodak, platinum bromide, etc. will yield density which is suitable for negatives. To prepare a gelatine bromide paper, the first requisite is to make an emulsion, and any of those given in Chapter XI. will answer, if to it be added about 30 minims per ounce (6 per cent.) of pure glycerine. If the climate in which it is to be used is very dry, as much as 60 drops (12 per cent.) may be employed. The reason of this addition is the necessity for keeping the paper pliable, when dry, after coating. A plan which answers very well in our hands is as follows:—Thick Saxe paper, an inch each way larger than is required, is damped with—

Water ...	... 1 ounce ...	... 8 *parts*
Glycerine ...	... 1 drachm ...	... 1 *part*

and fastened round a plate, turning over the ends and sides beneath it. The excess of moisture is blotted off, and the paper coated as if it were a glass plate. The difficulty of this plan is the tendency of the emulsion to run over the edges of the paper. To avoid this we have used a plate rather larger than the paper was required to be (an inch each way), and cut the paper to the exact size. The plate has been run round with an edging of gelatine and glycerine, so that the paper, when damped, adheres to it at its edges. The paper can now be coated without any tendency for the emulsion to leave the plate. When set, the paper can be transferred to another plate for drying, or can be pinned to a lath which is hung up by its corners in the drying cupboard. It might be thought that this edging of gelatine was superfluous, but it is not, as in practice it is found that without it a thin layer of emulsion penetrates beneath the paper by capillary attraction, and, on drying, prevents its leaving the glass.

Another very convenient method of preparing sheets of paper for negatives is by means of a *perfectly straight* glass tube (fig. 133) of the width of the paper, round the ends of which are two india-rubber rings, or pieces of thin wire, of the thickness of which the film is desired to be. The emulsion flows beneath the rod and gives an even coat.

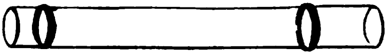

Fig. 133.

If thought advantageous, a rod may be passed through the tube and bent round to join, and so to form a handle. It is better that the tube should not revolve as it passes over the surface.

The paper is damped as before, and stretched on perfectly flat plate glass; the emulsion is poured gradually in front of the roller, and the emulsion takes a fine layer of a uniform thickness. For preparing paper for positives, a couple of sheets may be placed back to back, and together passed through a trough of emulsion, the two being raised vertically together, and dried together. The emulsion will not penetrate between the two sheets if properly manipulated.

Another plan, which we first saw in Mr. H. Starnes's hands, is very simple. The accompanying figure (134) shows the section of a box. The emulsion is poured into A, and the box, with the

Fig. 134.

emulsion in it, is placed on damp paper, the end, C, being placed at the edge of the paper; the box is then tilted; the emulsion flows into B, and flows through C, which is a fine slit (made by inserting a thin card during the making of the box, and afterwards withdrawing it). The slit may be covered with two fine pieces of muslin if thought necessary, and the flow is thereby regulated, as the end of the box is drawn over the paper, leaving a track of emulsion. It will be seen that the box, which in our case is made of well-shellacked wood, could be made of metal (nickelled iron, for instance, or silver), and a heating box introduced so as to keep the emulsion at a proper temperature. When the box comes to the end of the paper, the emulsion is tilted back from B into A. This plan also answers for coating plates.*

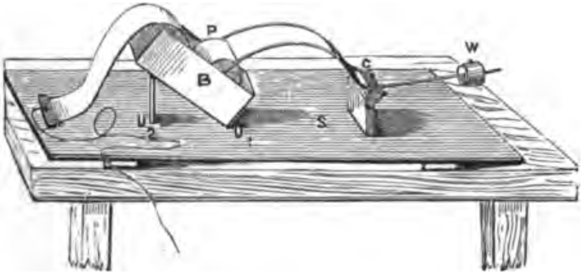

Fig. 135.

The following rough sketch (fig. 135) represents the model of a simple contrivance (designed by Messrs. Ashman and Offord consisting of a board or stand, S, with an upright upon which rocks a forked lever, C. One end of lever carries a small sliding weight of lead, W, provided with a screw to secure it at the proper distance from fulcrum at C. The points of the fork are drilled to take a wire which passes through the centre of a wooden roller, P, upon which the paper is coiled; one end of paper is gummed to the roller, the other fastened in practice between two slips of wood, by means of two or three brass screws or nuts, or by springs at each end, the inner surfaces of

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* For other methods and remarks on coating paper, see *Photography with Emulsions* (Sampson Low and Co.).

wood being roughed. To these slips of wood is attached a cord long enough to go to the ceiling of room, to pass through an eye or staple fixed there, and to hang just within reach of the upraised hand. Two little uprights on stand, U1 and U2, form a place in which to rest an ordinary deep, white earthenware photographic bath, at a suitable angle to form a V-trough which can receive the emulsion. In practice, the fork of the lever is better made of wood, shaped like the wire of the model. To coat strips, say, one-third the narrowest width of a sheet of Rive or Saxe, the paper is cut, and the ends joined with stout gum; the number of strips depends on height of room or position of stand, on floor or table. Care is taken that the roller is the same width as paper, and the laps in the latter are so made that each strip, beginning at the inner one, is under the next outer one, thereby presenting no edge of paper to cut against the surface of the emulsion, and so form waves; the right side of paper must, of course, be outside. The bath, having been warmed, is put into its place, the emulsion poured in, and the lever, with paper-covered roller, tilted on to the surface, being previously so balanced as to rest lightly thereon. One hand takes hold of the string, while the other touches the fork, and keeps it from rising by the tension of the cord; the cord is then slowly pulled until the whole of the paper has passed over the emulsion, when the roller is allowed to rise out of the trough, and the bath is removed.

Films on Celloidin.—In the market there are now many films on celloidin (which is simply a preparation of collodion which give excellent results. They are sufficiently stiff to be placed in the ordinary dark slide backed by a thin piece of wood, and they have no tendency, like paper, to ruckle from expansion and contraction due to varying hygroscopic conditions of the atmosphere.

It is unnecessary to enter into the details of how these films are coated; suffice it to say, that they can be sealed to a glass plate by a water film, and coated as if the surface were of glass. They are very light in comparison with glass; one sample, for instance, showed that thirteen films were only of the same weight as one thin glass plate of the same area. For tourists this is naturally of immense value, diminishing as it does the weight of baggage.

The Kodak Company have introduced a very much thinner film for holding the gelatine film, as thin or thinner than paper, but which requires almost to be used in a roller slide. To these we shall refer again in the chapter on hand-cameras.

Exposure and Development of the Negative Papers and Films.—The exposure of these papers is not quite the same as if a plate had been coated with the same emulsion. It is practically a little less, as the surface of the paper reflects back part of the effective light which in a glass plate passes through. With any transparent film we should, therefore, recommend that it be in contact with a white backing rather than a black one, if the extremest rapidity is to be obtained.

The alkaline developer (soda, potash, or ammonia), to which sulphite of soda has been added, may be used, or ferrous oxalate developer; but with the latter, when paper is used, care must be taken to avoid stains due to oxide of iron appearing. This is best effected by using, after development, a saturated aqueous solution of alum to which 1 per cent. of sulphuric acid has been added, or by the use of a 10 per cent. solution in water of acetic acid. In fact, any of the developers used for plates may be employed; if not, the writer would certainly refuse to trust to them. *In every case paper should be first soaked in clean water before the developer is applied*, and we recommend the same for celloidin films as well. We subjoin the Kodak developer, which is slightly different from those already referred to, and it gives excellent results.

No. 1.

Sodium sulphite crystals (pure) ...	6 ounces ...	264 *parts*
Distilled or boiled water... ...	40 „ ...	1,760 „
Pyrogallic acid	1 „ ...	44 „

No. 2.

Sodium carbonate (pure)... ...	¼ pound ...	1 *part*
Water	1 quart ...	10 *parts*

To develop, take in a suitable tray—

No. 1	1 ounce ...	1 *part*
No. 2	1 „ ...	1 „
Water	1 „ ...	1 „

Each ounce of this developer contains approximately 4 grains pyrogallic acid and 15 grains of sodium carbonate.

Immerse the exposed paper or film in clean cold water, and with a soft camel's-hair brush gently remove any adhering air-bells from the surface. If paper, as soon as limp transfer to the developer, taking care to avoid bubbles by gently lowering the paper by one edge, so as to slide it under the surface of the developer.

The image should appear in ten to twenty seconds, and the development should be carried on in the same way as for a glass dry plate. If the image appears too quickly, and is flat and full of detail, add five to ten drops of the restrainer—

Potassium bromide	1 ounce ...	1 *part*
Water	6 ounces ...	6 *parts*

This will keep back the shadows, and allow the high lights to attain density.

If the exposure has been too short, and the image does not appear except in the highest lights, add, instead of the restrainer, more of No. 2; this will help to bring out the details, and compensate in a measure for the short exposure.

As soon as sufficient density is obtained, slightly rinse the negative and put in the fixing bath—

Sodium hyposulphite	4 ounces ...	4 *parts*
Water	1 pint ...	20 ,,
Common alum *	½ ounce ...	½ *part*

To be mixed fresh for each batch of negatives.

The completion of the fixing operation may be ascertained by looking through the film. When fixed, wash in five or six changes of water for fifteen or twenty minutes, and then lay the paper negative, face down, upon a clean plate of glass or hard rubber that has been rubbed over with an oily rag. Press the negative into contact with the plate by the scraping action of a squeegee, and allow to dry, when it will peel off from the plate with a fine polished surface.

Oiling a Paper Negative.—Lay the negative down on a clean sheet of paper, and give it a coat of castor oil, applied with

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* We do not recommend this addition.

a rag. Then press it with a hot iron until it shows an even dark colour. Use plenty of oil. If the iron is too hot it will dry out the oil, and it will be necessary to go over it with the rag again. If the iron is not hot enough, it will fail to cause the oil to penetrate the paper sufficiently. Instead of using a hot iron, the negative may be held over the stove. When an even colour is obtained, wipe off the excess of oil with a soft cloth, and the negative is ready to print. The negative may be boiled in oil until the oil sinks into the paper. This expels the air in the paper and fills the pores, so that on examination it will be found that the grain has disappeared, leaving a fine ground-glass effect. No oil should be allowed to get on the face of the negative; in case it does, it may be removed with a cloth and a few drops of alcohol. Canada balsam and a solvent—such as turpentine or benzine—is also recommended by some as a substitute for the oil, and is effective.

Waxing the Negative.—We have found that the negative may be waxed instead of oiled, as the Kodak Company recommend, and for most paper, such as we have prepared, it is very efficient. The paper negative, when dried, is ready for waxing. A flat-iron should be warmed, and thoroughly cleaned by rubbing on emery cloth and blotting-paper, and a small cake of pure white wax be brought in contact with its point on the back of the negative. The heat melts a certain amount of the wax, which, by moving the iron, can be spread over any desired portion of the picture. Blotting-paper should then be placed over the negative, and the hot iron passed over the surface of the blotting-paper till all superfluous wax is removed. The negative is now fit for printing purposes.

Intensification.—We have found that the best intensifier to use is the mercury and ferrous oxalate given at page 186, and, further, we have found that it may be applied before or after rendering the paper transparent, always taking care in the latter case that the surface is free from oil or wax.

When a film is being developed, it may be treated precisely as a glass plate, though, as already stated, we prefer to soak it in water previously to it, to such an extent that the gelatine surface becomes slightly convex in the middle, owing to the expansion of the gelatine; this necessitates a slightly greater quantity of developer than for a glass plate.

CHAPTER XXI

DEFECTS IN GELATINE NEGATIVES

Frilling.—What is meant by frilling is the gelatine film leaving the glass plate in folds or wrinkles; and a greater nuisance than this cannot be met with. It generally occurs when fixing the plate, though we have sometimes met with it during the development, especially in hot weather. We will endeavour to state the causes of frilling as far as they are known. Frilling is often caused by the use of unsuitable gelatine, possessing but little tenacity. The more the qualities of gelatine are like glue, the less chance there is of meeting with this vexatious evil. If gelatine, however, were like glue in respect to hardness, the difficulty of developing a plate would be very great, since it is too hard. The addition of chrome alum to an emulsion also prevents frilling to a great extent. The objections to chrome alum are, that it increases the tenacity of the gelatine, and prevents easy development; hence it should be used sparingly.

Gelatine that has been heated for a long time has a special tendency to frill, and, unless fresh gelatine be added to the emulsion, in some cases frilling is inevitable. Long cooking (in warm weather particularly) means decomposition of the gelatine, and decomposed gelatine is very detrimental in preparing a dry plate. Boiling for a short time has much the same effect on the gelatine as cooking at a lower temperature; hence, to avoid frilling, it is better on the whole not to boil the emulsion with the full amount of gelatine.

Another source of frilling is the plate being improperly cleaned. If water will not flow in a uniform sheet from a plate, it may be well understood that there will be but little adhesion between it and an aqueous solution of gelatine. This we believe to be one fruitful source of the evil.

Another source of frilling is unequal drying. Thus, if plates be dried in an unventilated box, it will usually be found that a central patch refuses to dry till long after the outsides are completely desiccated. At the junction of this central patch with the neighbouring gelatine frilling is to be looked for. It will spread to the parts which have been the longest in drying. This is due to a false tension set up in the film, and can only be conquered by drying the plate by means of alcohol, or by using a proper drying cupboard.

Again, when plates are coated in hot weather, unless precautions are taken of cooling the slabs on which they are placed, they take long to set. The emulsion remains liquid on the plate for sufficient time to allow the heavier particles of silver bromide * to settle down on the surface of the glass. This, of course, diminishes the surface to which adhesion can take place. We believe that most of the frilling which takes place in plates prepared in hot weather may be traced to this cause. When washing after fixing, frilling is often caused by allowing a stream of water from the tap to impinge on the plate. This should never be allowed if the film is at all delicate. Plates which frill or blister will often not show any signs of so doing if kept for a few months.

A general remedy for frilling is to coat the plate with normal collodion containing about six grains of tough pyroxyline to the ounce of solvents. The formula would be thus :—

Tough pyroxyline	6 grains ...	6 *parts*
Alcohol (·820)	½ ounce ...	220 „
Ether (·720)	½ „ ...	220 „

This may be applied to the film immediately before developing the plate; the solvents are washed away in a dish of clean water first, and, when all repellent action is gone, the developing solutions applied. If the film has been allowed to dry, a solution of one part of ether to three of alcohol will render it pervious to the developing solutions.† In some batches of

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* This is particularly liable to happen when the emulsion has been long boiled or carelessly mixed.

† We have found this essential in intensifying negatives which have been treated with collodion after fixing and drying.

plates, frilling is so obstinate that, although collodion be applied, the film has a tendency to curl off from the edges of the plate. It is advisable, when such is suspected, to run a brush with an india-rubber solution round the edges, to prevent the water having access to that part of the film. When fixing such plates it not unfrequently happens that blisters appear, and, if allowed to remain as they were, will spoil the negative. To avoid this, we wash the plate under the tap till all the blisters join, and the film presents the appearance of a sac containing water. A prick at one corner of the plate lets this liquid free, and the washing can take place as usual. The obstinate cases of frilling usually occur through plates being prepared in very hot weather, and the film being dried without first setting.

Some writers state that, by immersing the plate in a saturated solution of Epsom salts, frilling is avoided; we have not succeeded ourselves in proving its efficacy.

Commercially prepared plates are not now much prone to this defect except in very warm weather. The causes which lead to frilling, and which should at all times be avoided, are: employing solutions at too high a temperature, transforming the plate from a solution at one temperature to another much warmer or colder, transferring the plate from a dense to a weak solution, and *vice versâ*, and the use of an excess of alkali.

Blisters on the Film.—Blisters on the film are the usual preliminaries to frilling. When they commence, further damage may usually be avoided by flooding the plate with methylated spirit. This extracts the water, and with it any soluble salt that may be left, and the plate speedily dries, which is an advantage if it be fixed. Blisters are usually found to follow the rubbing marks of the polishing cloth, if such be used. The cure here is self-evident. They also are to be found in places between which the film has dried quickly and slowly.

Red Fog.—The writer fortunately knows very little about this disaster, but it is found to occur if the silver nitrate is in excess of the salts with which it should combine. Cyanide will sometimes eliminate it from a film, but this remedy must be used with caution.

Green Fog.—This fog is green by reflected light, and pink by transmitted light, being dichroic. Experiment points to it being reduced metallic silver in an exceedingly fine state of division, this reduction being aided by decomposed gelatine. In some cases we have immersed the film in a strong solution of bichromate of potash, and on afterwards washing, the fog has disappeared; but whether it is a certain cure we hesitate to say; it is, at any rate, worth trying.

It is frequently present on orthochromatic plates, and on many foreign brands of plates, and is due to the use of ammonia in their manufacture.

The defect occurs most frequently when ammonia is used in the developer. For this reason it is desirable to use pyro-potash or pyro-soda developers in such cases. The newer developers mentioned in Chapter XVI. are free from the tendency to produce green fog.

The writer has recently found that green fog can be eliminated from a plate if, after fixing and washing, it is treated with a ferric salt. The following seems to answer satisfactorily:—

Ferric chloride ...	... 50 grains ...	50 *parts*
Potassium bromide	... 30 ,, ...	30 ,,
Water	... 4 ounces ...	1,760 ,,

This converts the image into silver bromide, and at the same time bleaches the green fog, which, seemingly, is a deposit of silver mixed with a constituent of gelatine. The plate is then washed to get rid of any great excess of the iron salt, when it is treated with ferric oxalate developer. This reduces the bromide, with slightly increased density, to the state of metallic silver, and the green fog is replaced by a very faint deposit of metallic silver, which in no way interferes with the printing. Green fog is never seen when using ferrous oxalate, which has not an alkaline reaction.

General Fog.—By general fog we mean the fog produced in development, caused by the partial reduction of the silver salt all over the film. This is probably due to the decomposition of the gelatine by long cooking, the products of which, in the presence of a developer, are apt to react on the silver salt, and produce a partial reduction in it. The production of this kind of fog, and electrical disturbance in the atmosphere, are apt to go together. In unfavourable weather, a few drops of a solution of carbolic acid should be added to the gelatine during boiling or prolonged emulsification; this will generally check or entirely prevent the decomposition. An excess of silver is likewise very likely to produce the evil, but the presence of iodide in the emulsion will almost certainly cure it. Another fruitful source of fog is the light admitted to the plates during preparation or development. The light should be tested by putting a plate in the dark slide, and drawing up half the front, and exposing the half-plate to the light for ten minutes. If the fog be due to this cause, the plate on development is sure to show it by a slight reduction of metallic silver in the part so exposed.

Whatever may be the cause of fog—if the emulsion be not hopelessly in fault, or if the plates have not seen light—we have found that, as in the collodio-bromide process, there is one certain sure cure. If the emulsion be slightly at fault, squeeze it into water containing 10 grains of potassium bichromate to each ounce, and allow it to rest for an hour, and then wash again for a couple of hours more. Plates may be treated in precisely the same manner, and give unveiled pictures. There is a slight diminution of sensitiveness if the bichromate be not all washed out, but nothing to hurt except where very great rapidity is required.

A cure for any emulsion is the addition of a few grains of cupric chloride. This diminishes the sensitiveness, but is most effectual, negatives yielding bright and brilliant images. A remarkable fact about the addition of the cupric chloride is, that the grey form of bromide is converted into the red form if much of the copper salt be employed. The addition of a few grains of ferricyanide of potassium with a little bromide of potassium (according to Dr. Eder) is also a perfect cure, but this slows the emulsion.

Flatness of Image is usually due to over-exposure and development with the alkaline developer; the use of ferrous oxalate mitigates the evil, whilst if iodide be in the film we have never found any great lack of density to arise. Feebleness of the image is also often caused by too thin a coating of emulsion, or an emulsion poor in silver salt. A thick film is a desideratum, giving all the necessary density to the image with facility. When a vigorous image is required, it is most readily obtained by using a freshly-prepared and strong ferrous oxalate solution.

Inexperienced workers frequently produce negatives lacking in density by the use of an excess of alkali or an insufficiency of the developing agent coupled with insufficient development. The remedy is to intensify the negative. The nature of the intensifier to be used depends upon the character of the image. When the contrasts require to be strongly accentuated, bleaching with mercury and bromide of potassium followed by cyanide of silver may be employed; when it is desired to obtain greater density without altering the gradation of the negative, bleaching with mercury followed by ferrous oxalate or by ammonia should be adopted; and when it is desired to add as much as possible to the strength of the shadow detail without unduly strengthening the lights, a light surface deposit of uranium or of Wellington's silver intensifier will meet the case. For details see pages 184 to 187.

Want of Density in a negative may be caused by over-exposure, but it more often arises from the emulsion itself.

A rapid emulsion has a tendency to give a feebler image than a slow emulsion, although to form the image the same amount of silver may be reduced. This shows that the silver is in such a state of aggregation that it does not possess what may be called covering powers. We have found that the addition of a chloride emulsion materially aids the production of density. If one-fifth part of an emulsion prepared according to Chapter XIX. be added to an emulsion lacking density-giving qualities, it will be secured without detriment to the sensitiveness. The range of sensitiveness will be slightly altered. A hard gelatine is also conducive to feeble images. If prepared plates give feeble images, resort must be had to intensifying.

Too Great Density of Image is sometimes met with, and can be remedied by applying ferric chloride to the film, and then subsequently immersing in the hyposulphite of soda fixing bath.

The formula recommended is—

Ferric chloride ...	1 drachm ...	6 *parts*
Water	4 ounces ...	176 ,,

This is flowed over the plate a short time, and then, after washing, the plate is immersed in the fixing bath. The solution acts very vigorously, and should be diluted if only a small reduction is required. Local reduction may be effected by using a paint brush charged with this solution on the moistened film. This practice is not, however, much to be commended, as it is rather working in the dark.

Density may also be diminished by the use of a strong solution of cyanide. Local reduction may be given by moistening the parts required to be reduced with water by a paint brush, and then applying the cyanide in the same manner. The reduction can be seen progressing.

There are a variety of formulæ extant for reducing negatives. Perhaps the best is eau-de-javelle, which can be obtained of all chemists, but which is made as follows:—

Dry chloride of lime ...	... 2 ounces ...	96 *parts*
Carbonate of potash	... 4 ,, ...	192 ,,
Water	... 30 ,, ...	1320 ,,

The lime is mixed with 30 ounces of the water, and the carbonate dissolved in the other 10 ounces. The solutions are mixed, boiled, and filtered. The filtered solutions should be diluted, and the plate immersed in it till reduction takes place. The plate should be fixed, and again washed. The most recent reducing agent is persulphate of ammonia.

The reducer known as Howard Farmer's is a useful one, as with it the amount of reduction taking place can be seen and checked at the right time.

Two or three small crystals of ferricyanide of potassium are rinsed in water to remove surface impurities, and are then dissolved to make a saturated solution. A few drops of this solution are added to a freshly-prepared bath of hyposulphite of soda of the usual fixing strength, and the plate is immersed till sufficient reduction has taken place.

As these reducers act from the surface of the film downward the shadow detail is reduced disproportionately to the high lights, and the gradation of the negative is entirely altered.

Until quite recently the only way in which an approach to regularity of reduction in the image could be affected was by reducing the surface deposit by one of the reducers already mentioned, after which the image was converted into bromide of silver or chloride of silver by bathing in a solution of chromic acid and bromide of potassium, or chromic acid and hydrochloric acid, when the image was partially developed and fixed before the high-lights were completely developed. As the process was very uncertain in its action it was not much used.

Persulphate of ammonium, which has been recently introduced, acts in a very different way. If a negative is immersed in a 2 per cent. solution the image will be reduced proportionately throughout, and the gradations remain unchanged. The effect is as if development had in the original instance been checked at an earlier period.

When sufficient reduction has taken place the plate should be transferred to a 5 per cent. solution of sulphite of soda and afterwards to the ordinary fixing bath to remove the silver salts which the persulphate of ammonia leaves in the film.

Other uses for persulphate of ammonia will be found referred to in other chapters of this book.

Yellow Stains.—Usually a yellowish veil appears to dim the brightness of the shadows when the development has been effected by the alkaline developer. This may be removed, if thought requisite, by the application of one or two drops of hydrochloric acid to an ounce of water, and flooding it over the surface of the plate. This must be done after the negative has been freed from hyposulphite, otherwise the acid decomposes this salt, and there is a deposition of sulphur. Mr. Cowell has recommended another clearing solution, which is made as follows :—

Alum	1 ounce ...	1 *part*
Citric acid...	2 ounces ...	2 *parts*
Water	10 „ ...	10 „

Mr. B. J. Edwards makes this solution sherry-coloured with ferric chloride, but we do not find any marked advantage in so doing. The film must be washed almost immediately, as the acid is apt to cause frilling.

Another formula is :—

Saturated solution of alum ...	20 ounces ...	40 *parts*
Hydrochloric acid	½ ounce ...	1 *part*

The negative should be well washed in all cases after the application of either of them.

The use of an acid fixing bath renders a clearing bath unnecessary. Some of these acid baths which have been recommended from time to time have a tendency to deposit sulphur in the film. The following, which is a favourite with Mr. E. J. Wall, appears to be free from that defect. Dissolve a quarter of an ounce of citric acid and half-an-ounce of sulphite of soda each in one ounce of water, mix and add this to twenty ounces of the ordinary solution (1 part in 4 of water) of hyposulphite of soda. This bath removes stains due to the developer, and at the same time hardens the film and reduces the risk of frilling.

Too Granular an Emulsion is usually due to bad mixing of the soluble bromide and the silver nitrate; but it may also be caused by over-boiling, and also by too small a quantity of gelatine in the boiling operation. Digesting too long with ammonia, as in Van Monckhoven's process, has the same effect. There is no cure for this evil.

Opaque Spots on a plate are almost invariably due to dust settling on the film when drying; they also may be due to imperfect filtering of the emulsion.

Semi-Transparent Spots on the plate before development are generally due to (1st) excrescences on the glass plate, or (2nd) to the use of gelatine containing grease.

As has already been pointed out, certain gelatines are apt to contain grease, and that so intimately that soaking in ether or washing with ammonia will not eliminate it. A specific is as follows:—We will suppose that 80 grains (parts) of Coignet's gelatine are required: 90 grains (parts) are weighed out, soaked in water, drained, and melted. The liquid is then very slowly poured, almost drop by drop, into methylated spirit, free from resin, where it is precipitated in shreds of a white pasty character; after it is all precipitated, the spirit is poured off, and a slight rinse with fresh spirit given, and then it is covered with water, in which it should remain till the whiteness disappears. The water should then be changed, and the gelatine drained and re-dissolved; about 10 parts out of the 90 seem to be dissolved in the mixture of alcohol and water. Emulsions made with this gelatine will be markedly free from grease spots.

The same method may be adopted for large quantities of gelatine, omitting the final wash with water, and leaving it to dry spontaneously. This is best done on glazed dishes. The gelatine can be broken up, weighed, and used in the usual manner. Another plan is to soak the gelatine in water with a full quantity of water; drain off what can be drained off, pressing the gelatine during draining. The gelatine is next melted, and to every 100 grains used, ¼ ounce of strong ammonia is added. When set, the gelatine is squeezed through netting, and washed till an alkaline re-action is only just shown on red litmus paper. All grease is saponified and washed out to a great extent. The gelatine may be added to the boiled emulsion in the moist condition.

Semi-Transparent Spots on a plate after development may often be traced to a fungoid growth in gelatine. The dark room in which plates are coated sometimes gives rise to this growth, damp and so on favouring it. The walls of the dark room should be antiseptically treated when such is suspected.

Dull Spots on the Negative are also due to the use of gelatine which contains greasy matter. They seem to be formed by the repellent action of the gelatine for the silver bromide. If a plate be carefully examined, the dull spots can be seen before development, and generally occur where the surface is denuded of gelatine, and, there being no restraining action by the gelatine, these are first reduced by the developer. If a plate which shows such repellent action be coated with a weak solution of gelatine or albumen, and then be dried, the evil will be much mitigated. The dull spots are usually met with in most aggravated form in hot weather, when the emulsion takes long to set, and, consequently, when the repellent action has longer to develop its power. In hot weather the slab should be cooled with ice to avoid this evil.

Pits are, in reality, an aggravated form of dull spots. The repellent action in this case is able not only to cause the gelatine to be repelled, but also to carry with it the bromide as well.

Irregular-shaped Spots, which refuse to develop, are often caused by the use of chrome alum in emulsions which contain free alkali. Ammonia causes a precipitate with chrome alum, and this encloses particles of bromide, and prevents the action of the developer upon it.

Transparent Pinholes on the Negative after Fixing may arise from minute air-bells in the emulsion, or from dust which finds its way into the slides or changing-box. The former disappear if the emulsion is kept before coating. The latter can be avoided by rubbing the dark slides with a minute trace of glycerine. This acts as a trap for the dust, and prevents its finding its way on the plates.

Dark Scratches on the Negative.—Sometimes plates on development show dark scratches which, at first sight, may appear unaccountable. If the plates have been rubbed together, or if any grit has been rubbed on them, this will account for the markings.

CHAPTER XXII

PREPARATIONS FOR WET PLATE PHOTOGRAPHY

THE sensitive salts of silver usually employed in the wet process are the iodide and bromo-iodide, the former being used only for special classes of work, to which attention will be drawn. The following is an outline of the process:—1st. Collodion is prepared in which are dissolved bromides and iodides. 2nd. A clean glass plate is coated with a thin film of this prepared collodion. 3rd. When set, the plate is immersed in a solution of silver nitrate (usually called the bath solution), which causes the formation of silver iodide or bromo-iodide. 4th. The plate is then exposed in the camera. 5th. A developing solution is applied to bring out the image. 6th. The image is intensified or strengthened. 7th. It is fixed. And 8th, a coating of varnish is given to the dried film to protect the delicate collodion surface. In this stage the negative is complete for printing purposes.

The Glass Plate.—A few remarks are necessary on the glass that should be selected for camera work. As a rule, patent plate is recommended by most authorities on the subject, as being perfectly flat and of a good polish. It must, however, be borne in mind that patent plate is really nothing more than sheet glass which has been ground to a flat surface and then polished. The outer skin of all glass is always the hardest and most compact portion, and since the patent plate is denuded of much of the original surface, the inner portions of the sheet glass are consequently exposed to the action of the chemicals employed. In practice it is found that this glass absorbs impurities during the photographic operations which cannot be eliminated; and it is almost useless to expect to use the same plate above three or four times—a serious consideration to the tyro in the art when the high price of the article is remembered.

Sheet glass is generally "true" in one direction, but slightly curved in the other; but its surface is hard, and well adapted for small-sized plates, where the curvature may be neglected. A good specimen of this glass is one to be recommended.

Crown glass, from the nature of its manufacture, has generally double curvature, and is to be employed for large plates with great caution, owing to its liability to snap in the printing frame, and to throw portions of the picture out of contact.

Flatted crown is not open to this objection, but if it be really flatted, its cost should be nearly that of patent plate. It has a hard surface, and when a true sample of it is to be obtained, there is nothing better that can be used.

For large plates, say over 15 in. by 12 in., patent plate is recommended; for the inferior sizes, flatted crown; or, failing this, the best sheet glass.

Flatted crown has only one surface that is smooth, the process of flattening (which consists in heating the ordinary crown to a red heat and allowing it to flatten on a plain surface) making the other slightly irregular.

Plate-Cleaning Solution.—In order to make a plate chemically clean, some body must be found which will free it from mechanical dirt—such as dust—and also from grease. Alcohol has the property of holding most kinds of the latter in solution; hence it generally forms the staple of a plate-cleaning formula. Any alkali will turn grease into soap, rendering it soluble in water; hence this is often recommended as an addition. To free a plate from mechanical dirt, insoluble powder of an impalpable description is found to answer well when made up in a paste; hence the employment of tripoli powder and rouge. Common whitening has the property of absorbing grease when dry; hence a cream of this made up with water is sometimes applied to a plate, allowed to dry, and rubbed off in that state. The usual formula for a plate-cleaning solution is tripoli powder; spirits of wine sufficient to form a thin cream; liquor ammonia about ten drops to each ounce of the cream. Rouge may be substituted for the tripoli powder, but unless it be of the finest nature it is liable to cause scratches. It has also the disadvantage of injuring the bath if any be carried into it by the plate.

Plates carrying old varnished negatives which are to be used again should be allowed to soak in soda and water (one ounce of washing soda to two pints of water). This will generally secure the film leaving the plate. Should the films be unvarnished, hot water may be employed to remove the collodion. In both cases the plates must be treated with the cleaning solution.

It may happen that plates are slightly scratched, and refuse to become clean by ordinary means. Resort may then be had to albumen, etc., as given for dry plates.

Collodion is a viscous fluid made by dissolving gun-cotton (*i. e.* pyroxyline) in a mixture, varying in proportions, of alcohol and sulphuric ether, and is employed in photography as a vehicle in which the sensitive salts of silver are held for the purposes of exposure in the camera, etc. It should be limpid, structureless, and should possess a certain amount of tenacity; it should be non-contractile, and be perfectly transparent when dry. All of these qualities may be present or absent, according to the kind of pyroxyline used. We propose to show how to prepare pyroxyline.

Pyroxyline is cotton or fibre (cellulose or lignine) which has been altered in chemical composition by treatment with a mixture of nitric and sulphuric acids, or an equivalent of the former. The change that takes place is due to the combination of nitrogen tetroxide with the cellulose or lignine. The chemical action may be symbolised as follows :—

$$\begin{array}{ccccccc}
\text{Cotton} & \text{and} & \text{Nitric Acid} & \text{and} & \text{Sulphuric Acid} & \text{form} & \text{Pyroxyline.} \\
C_6H_{10}O_5 & + & 2H.NO_3 & + & H_2SO_4 & = & C_6H_8(NO_2)_2O_5 \\
 & & \text{Sulphuric Acid,} & \text{and} & \text{Water} & & \\
 & + & H_2SO_4 & + & 2H_2O & &
\end{array}$$

The manufacture of pyroxyline is one of considerable difficulty, though not at all out of the range of ordinary skill.

First Process.

Sulphuric acid 1·845 at 60° F.	... ...	18 parts[*]
Nitric acid 1·360[†] ,,	... ...	8 ,,
Water	... ...	1 ,,

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[*] It need scarcely be said that great care must be taken to prevent the acid coming in contact with the skin or dress. An india-rubber apron and a pair of gloves are useful to save the one and the other from hurt.

[†] The nitric acid of the strength given in this formula is ordinary commercial, and sold as pure ; hence it is recommended for economy's sake to

The water is poured into a strongly-glazed porcelain basin, the nitric acid *next* added, and *lastly*, the sulphuric acid. The mixture is well stirred with a glass rod. The temperature will now be found to be somewhere about 180° F. (80° *C.*). It must be allowed to cool to 150° F. (60° *C.*), and this temperature must be maintained on a water-bath. A dozen balls of cotton-wool, weighing about thirty grams, should now be immersed separately in the fluid with the aid of a glass spatula. The cotton-wool ordinarily obtained in commerce is contaminated with resinous matter of a varying character. In order to eliminate this source of uncertainty, the cotton is well boiled in an alkaline carbonate (such as sodium carbonate), then *thoroughly* washed, and, finally, carefully dried.* In this state, if dropped into water, it will rapidly sink, whilst cotton-wool, in its ordinary condition, will float on the surface for an unlimited time. Each ball of cotton should be pressed separately against the sides of the basin till it is evident that the acids have soaked into the fibre. Care must be taken that each one is immersed at once. Failing this, a different chemical combination takes place, and nitrous fumes are given off, and the success of the operation will be vitiated. Immersing the dozen balls will take about ten minutes.† At the expiration of this time the whole of the cotton should be taken up between two glass spatulas, and as much of the acids as possible should be squeezed out against the sides of a clean porcelain capsule. The cotton should then be dashed into a large quantity of water, and washed in running or frequent changes of water for twenty-four hours. Finally, when it shows no acid reaction to blue litmus paper, it is dried in the sun or on a water-bath.

Second Process.

Sulphuric acid of commerce	6 fluid ounces
Dried potassium nitrate	3½ ounces (av.)
Water	1 fluid ounce
Prepared cotton-wool	60 grains

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use it. If the acid be anhydrous of 1·457 sp. gr., the quantity should be reduced to 6 parts, and 4½ parts of water be used instead of 1 part.

* Strutt's cotton as prepared for dentists may be used without further preparation. It has been freed from grease by steam under high pressure.

† This prevents the access of the air to the fluid, and consequent absorption of oxygen. A neglect of this precaution will increase the chance of nitrous fumes being evolved.

Mix the acid and water in a porcelain vessel, then add the nitrate (which has previously been dried on a metal plate to about 250°, and then pulverised) by degrees, stirring with a glass rod until all lumps disappear, and a transparent, viscous fluid is obtained. This will occupy several minutes.

The whole of the cotton-wool must now be separated into balls the size of a walnut, and immersed as stated in the first process, care being taken that the temperature is kept up to 150° (66° *C.*). The cotton is then left ten minutes, and washed as before. Mr. Hardwich states that the chances of failure in this process "are very slight if the sulphuric acid be sufficiently strong, and the sample of nitrate not too much contaminated with potassium chloride." If failure occur through the cotton dissolving in either of the mixtures, a drachm less water must be used.

The operation may be conjectured to be successful if the cotton tear easily in the hand, and if the original lumps cannot be easily separated. Should nothing but fragments of the lumps be detected, it is probable (if the acids used have been of the strength given above) that the temperature has been allowed to fall. When dry, the pyroxyline, on pulling by the hand, should break up into little bits, and not resemble the original cotton in texture.

The weight of good pyroxyline should be greater than the original cotton by about 25 per cent.

If the acids employed be too strong, the pyroxyline will have a heavier percentage of gain, and on solution yield a thick, glutinous collodion: whereas, if the acids have been too diluted, it will probably weigh less than the original cotton, and yield a collodion adhering firmly to the plate, but giving negatives of an abnormal softness. With this specimen any small particles of dust that may fall on the glass will form transparent marks.

The following are formulæ which experience has shown are good for making collodion:—

No. 1.

Pyroxyline ...	55 to 65 grains ...	13 *to* 15 *parts*
Alcohol ·802 ...	... 4½ ounces ...	... 450 ,,
Ether ·725 ...	... 5½ ,, ...	... 550 ,,

No. 2.

Pyroxyline	55 to 65 grains	13 *to* 15 *parts*
Alcohol ·820	5 ounces	500 ,,
Ether ·725	5 ,,	500 ,,

No. 1 is most suitable for winter, No. 2 for summer work. The more alcohol in proportion to the ether that is used, the slower will the collodion set. A limit, however, to the proportions that can be used arises from the fact that, if the alcohol be added in excess, the film which contains the sensitive salts of silver becomes streaky, and slow in securing the impressions of the photographic image; whilst, if there be an excess of ether, the film becomes too contractile, and has a tendency to split on drying. In mixing the collodion, the alcohol should be added first to the pyroxyline, as, by so doing, its solution is aided. It must also be remembered that the quantity of pyroxyline given above is dependent upon its quality—viz. if it tend to form a gelatinous or limpid collodion. In the former case, less must be used; whilst, in the latter, more may be added.

When plain collodion has been prepared, and is poured in a fine stream into water, it is found that a portion of the pyroxyline remains in solution in the water, the precipitated portion being of a finer quality than the original. If this be dried and made up into collodion once more, it yields a beautifully textureless film. Should this method of "refining" the pyroxyline be determined upon, cheaper solvents, and half the quantities given, may be employed in the first instance.

Iodides and bromides of metals or alkalies are added to the plain collodion, and when a film of this bromo-iodised collodion is formed on a plate, and then immersed in a solution of silver nitrate, a free layer of silver iodide and bromide is formed. If iodides are used alone, the developed image is usually dense, with but little detail in the high-lights or shadows. The fact is, that in the high-lights the detail is present, but is clogged by silver deposit, which is due to the prolonged exposure which is necessary to give detail in the shadows.

Bromides used by themselves give a flatter image, but, as might be expected, full of detail, and the time required to impress a latent image on the sensitised film is shorter than when iodides alone are employed. It is thus evident that a judicious mixture of the two will give a film which, when sensitised, gives a mean between the delicacy of the bromide and the density of the iodide, whilst the time of exposure will be somewhat between that required for the two separately.

There is no doubt that the effect of different metals in combination with the halogen has some effect on the qualities of the collodion. Thus, ferrous bromide has a tendency to cause the pyroxyline to revert to its original state of cotton. It is therefore evident that, in choosing iodisers, this must be taken into account.

The iodides and bromides of zinc, potassium, ammonium, and cadmium, have all been tried by various makers. The two last are the staple iodisers and bromisers employed.

The following is a standard that has been found to answer well:—

No. 1.—Cadmium* iodide	4½ grains	4½ *parts*	
Cadmium bromide	2 ,,	2 ,,	
Plain collodion...	1 ounce	440 ,,	
No. 2.—Ammonium iodide	3 grains	3 ,,	
Cadmium iodide	½ grain	½ *part*	
Ammonium bromide	1⅔ grains	1⅔ *parts*	
Plain collodion...	1 ounce	440 ,,	

No. 1 should be mixed at least six months before use; it then gives a delicate image and fine detail.

No. 2 may be used after mixing two or three days, and is a good "general purpose" collodion.

The following general rules may be given for modifying the tendencies of collodion:—

A.—If a decrease of contrast and more detail be required, add bromide.

B.—If violent contrasts are wanted, the iodides should be increased and the bromides diminished. One quarter-grain of bromide to the ounce of collodion is found to be sufficient to secure cleanness in the shadows, and all but this quantity may be left out if necessary.

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* Cadmium renders collodion glutinous on first iodising. When kept it becomes more limpid. Ammonium fits collodion for more immediate use, as it does not cause it to become glutinous, even on first iodising.

As before stated, for certain classes of work it may be necessary to resort to simply iodised collodion, no bromide being admissible. The following are formulæ which have been adopted :—

No. 3.—Ammonium iodide	... 4 grains	... 1	*part*
Plain collodion ...	... 1 ounce	... 110	*parts*
No. 4.—Cadmium iodide...	... 5 grains	... 1¼	,,
Plain collodion ...	... 1 ounce	... 110	,,

No. 3 should be iodised almost immediately before use.

No. 4 requires keeping, and is a most stable collodion.

It should here be noted that it is customary, though not necessary, to leave out half the alcohol from the plain collodion, and dissolve the iodide or bromide in the quantity thus omitted. This procedure has advantages, and may be followed if considered convenient.

Collodion should be stored in a dry and cool place to prevent the ether decomposing, which, in its turn, decomposes the pyroxyline. Collodion made with pure spirit and neutral cotton will be colourless after iodising, but, if made with impure solvents, it will become first dark, but may afterwards return to its colourless condition. Should the pyroxyline be acid (not sufficiently washed after preparation), the collodion will become sherry-coloured almost immediately, but will not keep in good working condition for long.*

Methylated alcohol and ether are often employed by manufacturers as solvents. Experience teaches that, although apparently harmless at first, they both, particularly the former, contaminate the silver nitrate bath if used for any length of time. It is also noticeable that a collodion made with pure solvents frequently refuses to work in a bath to which methylated solvents have had access.

Collodion should be always labelled and dated after manufacture and iodising. This precaution will be found of the greatest use in selecting a specimen suitable for any particular purpose.

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* The contact of iodine with ether compounds is apt to form an organic compound. There is also a possible formation of aldehyde and acetic acid, the formation of which reduces silver from the nitrate solution.

When the iodised collodion is of a pale straw colour, it is in its most sensitive condition, and this may be produced by adding a few drops of tincture of iodine. A certain amount of free iodine is almost a necessity to obtain bright pictures; with methylated solvents more particularly, the colour may disappear after a time, and then more iodine must be added. After the iodised collodion spontaneously assumes the dark brown sherry colour, from the liberation of iodine,* it becomes less sensitive, and is more apt to give harsh pictures.

After plain collodion has been made, it should be allowed to stand till it is perfectly bright through the deposition of a fine sediment, when the top should be decanted or syphoned off. It should be tested before iodising. A plate should be coated, and it should be observed if it dry with any opalescence. Next, the film should be tested to see if it be powdery, or if it come away in strips to the touch of the finger. After it is iodised it should be tried by taking two or three negatives, the behaviour of the films being carefully noted. It is useful to have a sample of good standard collodion at hand with which to compare it. If the two halves of a stereoscopic plate be coated with the two collodions respectively, and the sensitised films be exposed simultaneously, their relative sensitiveness and densities may be readily determined, and the result should be noted for future guidance. Any defect in the collodion should of course be corrected.

Collodion which yields a thick creamy film gives a "plucky" image, whilst a limpid collodion gives one thin and transparent. This latter can be improved by adding a grain or two of pyroxyline to each fluid ounce. Should this defect arise from the use of alcohol which is too anhydrous, it may be rectified by the addition of a drop of water to each fluid ounce. Collodion that has been iodised a long time often has this defect.

It will be found advantageous at times to mix the collodions prepared by different formulæ; thus, a collodion yielding great intensity of image should be mixed for general purposes with one which is deficient in this quality. This remark applies not only to home-made, but also to commercially supplied collodions.

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* The whole of the iodine must be liberated before any bromine can be found in a free state.

When testing the plain collodion, should the film dry matt, the sample must be rejected, as the pyroxyline must be unsuitable.

Should the film, after sensitising, appear like watered silk, then the collodion is too alcoholic, or else contains too much iodide and bromide. The probable cure for this is the addition of a drachm to the ounce of plain collodion prepared according to formula No. 1, page 217. Should the defect arise solely from the collodion being too alcoholic, it is probable that if the film be allowed to set more thoroughly before sensitising, a cure will be effected. When collodion is under-iodised, the developed image will be poor and flat, though it is necessary to distinguish between this cause for the defect, and that due to impurities in the negative bath.

If the film, on drying, show "crape markings," the plain collodion has been prepared with solvents of too great a specific gravity—*i.e.* with too much water in their composition. To remedy this defect, an iodised collodion, formed of absolute ether and alcohol, should be added till the markings disappear.

Should the collodion, on setting, prove of a horny, repellent nature, the defect may be mitigated by shaking it up with a small quantity of carbonate of soda, and decanting the supernatant liquid from the residue. A drop or two of water to the ounce will frequently answer the same purpose.

If collodion be made up with absolute alcohol and ether, and the above amount of iodides and bromides, it will be found that the plate has the appearance of being stained with opaque streaks, especially at the corner of the plate from which the collodion was poured off, where, consequently, it was least set. To remedy this, it is a good plan to add water to half the amount of collodion, till it appears, on the withdrawal of the plate from the bath, to have the appearance of crape, then to add the remaining half to that portion which was watered. On trying a plate, it will be found that the film has lost the streaks, and is more dense than before. The amount of water that can be added depends a good deal on the quality of the pyroxyline.

The Sensitising Bath.—The strength of the sensitising bath is of the utmost importance in photography, as is also the purity of its constituents. The silver salt employed is invariably the silver nitrate, as it is the form most attainable in commerce, and can generally be procured free from impurity. Silver nitrate is readily soluble in its own weight of cold water, and in a still higher degree in hot water; but for the purpose to which it is to be put in the present instance a far weaker solution is preferable. When iodides or bromides are used in the collodion, the utmost strength admissible is (10 per cent. solution) 50 grains of silver nitrate to each ounce of water. For ordinary use even this proportion is too large, since silver nitrate in solution will dissolve up a certain amount of iodide of silver,* the quantity depending upon the strength of the silver solution, and on the temperature. If the solution were not, therefore, saturated with the silver iodide, on the immersion of a collodion film the silver iodide would be partially or wholly dissolved out, according to the time of immersion. Now, it is easier to saturate a dilute than a strong solution, and a variation in temperature causes a less marked difference with the former than with the latter. It is therefore evident that the less silver salt in solution, the more likely it is that the solution will not show signs of under or over-saturation of iodide.

The acidity or alkalinity of the bath is a condition to which it is necessary to give attention, the sensitiveness of the plate being dependent in a great measure on it. When simply iodised (with no bromide) collodion is used, the solution should be strictly neutral, or very slightly acid; whilst with a bromo-iodised collodion it should be decidedly more acid, unless there be a large amount of free iodine present in the collodion. By a reference to page 4 it will be seen that the presence of the iodine will cause the liberation of the nitric acid in the film itself, and this is almost more effective than the presence of the acid in the silver nitrate solution, since the action of the nitric acid is more local. The sensitiveness of the plate is dependent, to a great extent, on the purity of the water employed. Distilled water is naturally the most free from impurities, though even in it they are to be met with, unless great precautions are taken to eliminate them. When distilled water is not obtainable, water well boiled and filtered through charcoal (as given) should be used, though if rain

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* It will dissolve scarcely any silver chloride or bromide, hence it is unnecessary to saturate it with these salts.

water, *not* obtained from the roofs of town houses (or from the roofs of country houses, unless they have been thoroughly washed previously by a heavy downfall of rain), can be procured, it may be substituted with tolerable safety.

The following formula may be used for an ordinary negative bath when bromo-iodised collodion is used:—

Re-crystallised silver nitrate ...	40 grains ...	40 *parts*
Distilled water	1 ounce ...	440 „
Potassium iodide*...	$\frac{1}{8}$ grain ...	$\frac{1}{8}$ *part*

Take a quarter of the quantity of water that is to be used, and dissolve the silver nitrate in it; then add the potassium iodide or other soluble iodide. It will produce an emulsion of silver iodide, which will be partially re-dissolved on agitation. Next add the remaining quantity of water, which will cause a re-emulsification of silver iodide. After filtration the bath solution should be tested for acidity or alkalinity. Blue litmus paper should redden slightly after a minute's immersion. Should the red colour be produced immediately, a little sodium carbonate should be added till a slight precipitate is produced. This should be filtered out, and the bath acidified with a few drops of a solution of nitric acid (1 drop of nitric acid to 12 drops of water). Acetic acid is sometimes recommended for acidifying the bath. If it be used, silver acetate is after a time formed, which is injurious to sensitiveness and cleanliness of work, and cannot be eliminated by any convenient method. Should the test-paper refuse to redden, the nitric acid solution should be added. As a rule, if re-crystallised silver nitrate be used, the bath will require the addition of neither alkali nor acid.

Before taking a bath solution (or *bath*, as it will be hereafter called, for brevity) into general use, it should be tested. This is best done by immersing in it a plate coated with collodion. When fully sensitised the plate should be placed

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* Some prefer not to add any iodide to the bath, but allow it to become saturated by work. If a plate be moved about continuously in a bath made *minus* the iodide, there need be no fear of pinholes. It should be stated that, with a solution of greater strength than that given, it is very difficult to avoid them, even when adopting this method of procedure.

in the dark slide, *half* of it exposed to white light. It should then be developed. A trace of fog on the part to which the light had no access will denote that a slight addition of nitric acid is required, or that some impurity is present in the bath. The latter case will be considered when treating of the defects in negatives.

CHAPTER XXIII

DEVELOPERS AND INTENSIFIERS FOR WET PLATES

Developers.—Acid developers may be divided into two great sub-divisions : iron and pyrogallic acid.

Pyrogallic acid developers are now rarely used, since it was discovered that ferrous sulphate was the better reducing agent. When iodised collodion is employed without a bromide in solution, pyrogallic acid may still be utilised. It gives a very dense image, and is found useful for copying purposes, though a longer exposure of the sensitive film to the action of light is required than is necessary if the ferrous sulphate be used.

A good formula for a pyrogallic acid developer for negatives and positives is as follows :—

Pyrogallic acid	1 grain	1 *part*
Glacial acetic acid ...	20 minims	20 *parts*
Alcohol	*quant. suff.*	
Water	1 ounce	440 „

Since iron developers have been introduced there have been more modifications in the formulæ used. The following formulæ are applicable to the production of negatives, and will be found of the greatest utility :—

No. 1.

Ferrous sulphate ...	10 grains	10 *parts*
Glacial acetic acid	15 to 20 minims ...	15 *to* 20 „
Alcohol	*quant. suff.*	
Water	1 ounce	440 *parts*

No. 2.

Ferrous sulphate ...	30 grains	30 *parts*
Glacial acetic acid ...	20 minims	20 „
Alcohol	*quant. suff.*	
Water	1 ounce	440 „

The action of the different strengths of developers has already been pointed out, from which it will be gathered that in a weak light, without sunshine, No. 1 would be used; in bright light, No. 2.

The double sulphate of iron and ammonia has been employed as a developing agent with great success. It gives great delicacy to the image, and has the property of keeping a long time in solution without change.

No. 3.

Ammonio-sulphate of iron	25 grains	25 *parts*
Glacial acetic acid ...	25 minims	25 „
Water	1 ounce	440 „
Alcohol	*quant. suff.*	

The addition of different organic substances to the developer has been proposed by various photographers. The following is one to be recommended :—

No. 4.

Ferrous sulphate ...	20 grains	20 *parts*
Glacial acetic acid ...	10 minims	10 „
Gelatine *	1 grain	1 *part*
Alcohol	*quant. suff.*	
Water	1 ounce	440 *parts*

The addition of these "organifiers," as they popularly are termed, has an effect on the colour of the image, owing to the silver being deposited more slowly. The addition of gelatine

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* The gelatine should be first swelled up by cold water. Afterwards it should be dissolved by heat, and then the acetic acid added to it.

requires the action of light to be more prolonged to yield equivalent detail. Great density in a negative is yielded, but generally at the expense of the half-tones. They are not, as a rule, to be recommended, excepting for winter work, for copying plans, or for producing great contrasts in a landscape.

In all cases the ferrous sulphate will, after a certain time, absorb oxygen from the atmosphere and become ferric sulphate. As ferric sulphate will absorb no more oxygen, it is evident that its developing powers are lost, and, in fact, it is found that it acts as a retarder and even a destroyer of the image. The change in the salt of iron is shown by a red, rusty colouration of the developer. This colour may become visible, in hot weather, two or three days after the solutions are mixed; in colder weather a longer time elapses before the formation of any distinguishable ferric salt. A little ferric sulphate in the solution tends to keep the shadows in a negative bright, acting somewhat similarly to acetic acid.

In time, the crystals of the ferrous sulphate slightly decompose, a yellowish powder forming on their faces. This is due to the formation of an insoluble oxide of iron. Allowance in weight should be made for this.

With a new bath containing little or no alcohol, developers may be employed without the addition of any alcohol. After the bath has been worked for some time, it gets impregnated with the collodion solvents, and then the alcohol (*quant. suff.*) must be added to cause the developer to flow without repulsion; fifteen to twenty minims per ounce of water will generally be the quantity required.

Intensifiers.—The following are formulæ for "density" (see Chapter IV.) intensifiers:—

No. 1.

Pyrogallic acid ...	2 grains ...	... 2 *parts*
Citric acid ...	... 2 to 4 „ ...	... 2 *to* 4 „
Water ...	... 1 „ ...	... 440 „

No. 2.

Ferrous sulphate ...	5 „ ...	... 5 *parts*
Citric acid ...	... 10 „ ...	... 10 „
Water ...	... 1 ounce ...	... 440 „

No. 3.—An ordinary developer without alcohol.

Nos. 2 and 3 are usually employed in portraiture, and they are unusually efficacious in bringing out detail.

No. 1 brings up density more quickly than Nos. 2 and 3, and acts well for a properly exposed picture. Any of the above may be used either before or after fixing. To each a few drops of a 10-grain (a 2 per cent.) solution of silver nitrate should be added immediately before it is applied to the negative.

The next formula is for changing the metallic silver, after the image is fixed, to the state of iodide:—

No. 4.

Iodine	1 grain	1 *part*
Potassium iodide* ...	2 grains	2 *parts*
Water	1 ounce	440 „

After this solution has been applied to the film, any of the following may be used to cause the formation of a non-actinic colour.

No. 5.

Potassium permanganate	18 grains	18 *parts*
Water	1 ounce	440 „

This is most easily applied by immersing the plate in a flat dish containing the solution till the image appears of a yellowish colour throughout. The potassium permanganate is decomposed on coming in contact with the silver iodide, and parts with its oxygen, which combines with the silver; at the same time, the insoluble binoxide of manganese is precipitated on the image.

No. 6.

Uranic sulphate or nitrate	1 drachm	60 *parts*
Potassium ferricyanide	1 „	60 „
Gold terchloride ...	1 grain	1 *part*
Water	20 ounces	8800 *parts*

The colour of the deposit by this intensifier is changed to a

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* Iodine is very sparingly soluble in water; if potassium iodide be added, complete solution takes place.

rich chocolate brown. The solution should be used in a flat dish.

No. 7.

Mercuric chloride* (corrosive sublimate)	20 grains	20 *parts*
Ammonium chloride ...	20 „	20 „
Water	1 ounce	440 „

With No. 7 the following solutions may be used, should sufficient density (as would be the case in copying plans) not be obtained. The reactions that take place when employing them have been explained in Chapter IV.

Ammonium sulphide ...	1 ounce	1 *part*
Water	30 ounces	30 *parts*

Or,

Potassium cyanide	5 grains	5 *parts*
Water	1 ounce	440 „

Silver nitrate to be added till a permanent precipitate is obtained. This last solution should stand a night before it is used.

Or,

Ammonia	1 drachm	1 *part*
Water	1 ounce	8 *parts*

Nos. 4, 5, 6, and 7 must not be applied until the image has been fixed.

An intensifier which has met with much favour is made as follows :—

No. 8.

50 grains of copper sulphate in water	1 ounce ...	5 *in* 44 *parts*
30 grains of potassium bromide in water	1 „ ...	3 *in* 44 „

The mixture is flowed over the fixed image till it is perfectly

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* Mercuric chloride is only sparingly soluble in water; the addition of ammonium chloride causes it to dissolve readily.

blanched. After thoroughly washing under a good stream of water, the image is flowed over with a 100-grain (23 per cent.) solution of silver nitrate, when an intense black will be produced. The first solution produces silver bromide and copper sub-bromide; the latter leaves the bromide unchanged; but the copper sub-bromide is converted into silver sub-bromide (see page 29).

Eder and Toth intensify with the following solution :—

No. 9.

Plumbic nitrate	20 grains	2 *parts*
Potassium ferricyanide ...	30 „	3 „
Water	1 ounce	44 „

The plate is well washed, after fixing, with fairly pure water (free from sulphates), and is immersed till the image becomes opaque. It is again washed till the transparent parts are free from any deposit which may be on them, when it is treated with

Ammonium sulphide	1 *part*
Water...	5 *parts*

When the sensitive film has been exposed, and developed sufficiently to bring out the detail of the image, and when there is no tendency for the shadows to be "fogged" or veiled, intensification, *by increase of density*, should take place *before* fixing; if there has been over-exposure, *after* fixing. With an over-exposed picture, intensification before fixing acts as a development, and would cause fog; in most cases it is wise, before using the intensifier, after fixing, to flood the plate with No. 4.

Fixing Solutions.—The following are the formulæ usually adopted :—

No. 1.

Sodium hyposulphite ...	1 ounce	1 *part*
Water	6 ounces	6 *parts*

No. 2.

Potassium cyanide ...	25 grains	25 *parts*
Water	1 ounce	440 „

Varnishes.—Varnish is used to give protection to the delicate collodion film. It is simply a resin or resins dissolved in spirit of some description. When the solvent evaporates spontaneously, or by aid of heat, a thin layer of the resin is left, which gives the necessary toughness to the image to prevent damage in printing operations.

As a rule, it may be stated that the more colourless a varnish, the more suitable it is for negatives.

The solvent used for varnishes is usually methylated alcohol. Undiluted wood spirit is a solvent of pyroxyline; it is important that the specific gravity of the solvent should be so great that the image may not be dissolved away with the film. It should also be noted that the resin dissolved in pure alcohol of low specific gravity will dissolve pyroxyline, hence varnish should not be made with absolute alcohol.

The proportions of the constituents of most photographic varnishes are, as a rule, trade secrets; but the following answer well:—

Alcohol	16 ounces	16 *parts*
Unbleached lac*	2 "	2 "
Sandarac	2 "	2 "
Canada balsam	1 drachm	$\frac{1}{8}$ *part*
Oil of thyme or lavender ...	1 ounce	1 "

The resin should be dissolved in the alcohol by means of a water bath. The plate should be warmed as hereafter to be described, heat aiding hard and bright drying of the varnishes.

Seed-lac	1 pound	1 *part*
Methylated spirit ...	1 gallon	10 *parts*

The seed-lac is allowed to remain in contact with the solvent two or three days, shaking at intervals to avoid solution. The clear liquid is then decanted off, and thinned down (if necessary) to a proper fluidity.

Amber varnish, which is applied to a cold plate, is made as follows:—

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* Bleached lac absorbs moisture, and tends to make the varnish crack.

No. 1.

Amber (in fine powder) ...	1 ounce	1 *part*
Chloroform	16 ounces	16 *parts*

Or, No. 2.

Amber	1 ounce	1 *part*
Benzole	16 ounces	16 *parts*

The amber should be heated in a closed vessel to a temperature of 570° Fah., when it will begin to soften. It can then be dissolved readily by the solvents.

In some cases but few prints may be required from a negative. As a resinous-varnished film is difficult to wash off the glass, the following may be substituted for the spirituous varnish :—

Albumen	1 *part*
Water	3 *parts*

A dilute solution of gum-arabic may be used instead. In both cases the drying of the flim should take place spontaneously. If the collodion film be dry, it should be wetted previous to the application of the albumen or gum solution.

CHAPTER XXIV

MANIPULATION IN WET-PLATE PHOTOGRAPHY

Cleaning the Plate.—It is advisable to grind the edges of the plate previous to taking it into use. This may be effected by a corundum file supplied for the purpose by most dealers. An ordinary fine file will answer, but it is then a good precaution to moisten it with a little turpentine, to prevent the fine particles of glass * from flying on to the surface of the plate. Turpentine also gives a better bite to the file. Failing these implements, the edge of one plate may be drawn against the edge of another, which will partly accomplish what is desired. The tip of the thumb-nail should now be passed over both surfaces of the plate, to ascertain what was polished in the manufacture. The unpolished surface generally feels gritty to the touch. If both surfaces feel rough, the plate should be immersed in nitric acid and water, and allowed to soak for a few hours. It should then be washed under the tap, and allowed to drain. If there be many plates to drain, they should be kept separate from one another.† A good method is to stand them on edge on the floor or table, so as to support one another, as we see children make cards support one another in building a card house. When drained, the tripoli powder solution should be applied to the plates with a tuft of cotton-wool or old rag. A small quantity, sufficient to form a pool the size of a sixpence, may be poured on the plate, and rubbed well over the surface. It is sometimes recommended

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* When subsequently cleaned they might cause scratches on the surface.

† If the water contain chalk or other soluble solid impurity, so that the edge of one, if allowed to rest against the surface of another plate, forms an opaque chalky mark on the latter, this will entail the application of acid once more.

to let this dry, but, as a rule, it is preferable to remove it whilst moist, taking care that there is no arrest of motion before the surface appears bright. A diaper duster, which has been well washed in plain water and then dried, should be employed to rub off the cleaning solution.

A perfectly dry silk handkerchief or chamois leather should be reserved to give the final polish. (These should be well washed in sodium carbonate, or pearl-ash and water, then well rinsed, and finally dried, before use.) The motion of polishing the plate should be light, and in a circular direction. Polishing generates electricity, positive on the plate, and negative on the rubber, and electricity prevents the adhesion of the collodion film to the glass; but the electricity may be dissipated by passing a handkerchief or cloth *very* slowly over the surface. This allows the re-combination of the two electricities.

If the polishing be complete, condensed breath should leave the plate in a regular and even manner. When breathing on a plate, the mouth should be kept near the edge, and almost on a level with the upper surface, and care should be taken that no small particles of saliva fall on it. The moisture from the breath should be fully dissipated before an attempt is made to repolish. If not, transparent patches on the plate will be visible when it is breathed on again. A golden rule to remember is, that *every plate has two surfaces to be cleaned.*

When plates are old, they will not always polish properly, however much care may be taken. In such a case, a dilute solution of albumen and water may be applied with the Blanchard brush with good effect (see "Collodion Dry Plate"). The writer contends, however, that a properly cleaned plate is always safer than one so treated. This mode of preparing surface with albumen is often caused from laziness rather than from absolute necessity.

Clean plates can be well stored in absolute contact with one another, provided they are tightly packed. If loosely packed, any small particle of grit that may get between them will be liable to cause scratches on the surfaces. Another method of storage is in plate-boxes. This is not satisfactory, since all glass in contact with the air is liable to attract moisture and greasy matter. Clean blotting-paper is the best substance in which to pack clean plates.

Coating the Plates with Collodion.—It is inadvisable to coat a plate with collodion from a bottle which can contain more than five or six ounces, and a bottle of this size should only be filled up to an inch or so below the neck. A large bottle is unwieldy, and the collodion is apt to run down the side of a completely filled bottle. Convenient pouring bottles for the dark-room have been introduced, but for out-door work the ordinary six-ounce bottles * will answer well. It is recommended that corks should replace glass stoppers; the former clean the inside of the neck of the bottle from the thick collodion, whilst the latter are apt either to stick fast, or to be forced out by the ether vapour when the weather is warm.

If practicable, the collodion from the plate should not be returned into the same bottle as that from which it was poured, as any floating dust which fell upon it whilst coating one plate would probably appear on the next. Owing to the evaporation of ether, collodion in time will become too thick for use, and must be thinned with a mixture of one part of alcohol (·805) to two parts of ether (·730).

Dust should be removed from the plate with a broad badger-hair brush before coating. The brush must be perfectly dry, and care should be taken not to generate electricity by too vigorous a motion.

In coating a plate, the use of a pneumatic plate-holder † is a great comfort. If it be used, it should occupy the centre of the plate, as shown in the figure by P. The plate should be held at first horizontally, corners 1 and 2 being away from the manipulator. The collodion should be poured on to a spot S, the mouth of the bottle being as nearly as possible in contact with the plate, in order to avoid the formation of air-bubbles. S is fixed by the fact that the wave of collodion should reach corner 1 when such a quantity is on the plate as is just sufficient (or barely more) to cover a circular patch of the width of the plate. The collodion wave should then be caused to flow to 2, next to 3, and finally the excess should be poured off at 4. The wave should be directed successively to these

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* A broad lip aids much in securing a uniform flow, and prevents the collodion running down the outside of the bottle.

† One holder should be religiously preserved for collodionising the plate, and for no other purpose; another one should be set aside for the developing and fixing operations.

points by slightly tilting the plate. Whilst the collodion is being poured off at 4, the plate should be rather more tilted, till the excess has been drained off, after which it should be made to assume a nearly horizontal position, a slight inclination in the direction of 4, however, still being preserved. A gentle rocking motion should now be given to the plate, but there should be no grinding of the glass from the edges of the plate against the neck of the bottle, as small particles of glass might fall into the collodion, and appear as imperfections in subsequent films.

The collodion wave should not pass twice over the same spot, especially near corners 1 and 2. If it does, the almost invariable result is the thickening of the film at that place, which has the appearance of a drooping "curtain" by transmitted light. Should any air-bubbles spoil the surface of the film, a second coating of collodion may be given. This will generally correct the fault.

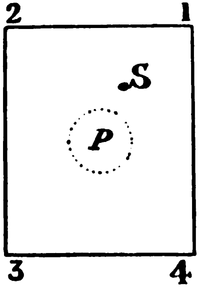

Fig. 136.

Should no pneumatic plate-holder be at hand, the plate, if of moderate size, should be held by the thumb and middle of the first finger by corner 2, the extreme point of the corner alone being held by the cushion of the thumb. The manner of holding will enable the entire plate to be covered, and the disfigured uncoated triangular portion at corner 2, so often seen, will be avoided.

When the plate is of such dimensions as to cause the above method of holding the plate to be inconvenient, a valuable auxiliary is a bottle weighted with shot. A wooden ball covered with chamois leather has a rod inserted in it, the other end of which is fixed in the neck of the bottle. To coat a plate with its aid, one corner rests on the ball, and the opposite corner is held by the fingers, as before indicated.

When the collodion at 4 refuses to drop, and the film at 2 appears to the finger to be in a tacky state, the plate is ready for immersion in the bath. This "setting" of the film, as it is technically termed, is brought about by the partial evaporation of the ether and alcohol from the collodion.

In hot weather one minute will generally suffice to cause setting, whilst in cold weather five or six minutes, or more, will be necessary. It is important that the right moment should be seized for immersing the plate in the bath, since defects in the film may make their appearance on development or during sensitising if the collodion be insufficiently or too much set.

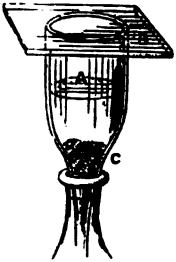

Fig. 137.

It has, of course, been supposed that the manipulator has examined his collodion to ascertain if it be free from small particles of undissolved pyroxyline or dust, also that no incrustation is on the neck of the bottle. The former will give plates which are specky in appearance, whilst the latter will soon tell its own tale.

Collodion should, if practicable, be decanted from a larger into a smaller pouring-bottle, either by means of a syphon arrangement, as usually employed in the laboratory, or by carefully pouring off the top layer of the fluid. Collodion-holders are to be obtained, holding from a quart upwards, which have a glass stop-cock inserted about 1½ inches from the bottom. With this arrangement the collodion can be drawn off free from sediment. It, however, frequently occurs that even decantation will not free the collodion from small floating particles. When this is the case, resort must be had to filtration. A convenient filter is to be obtained from Messrs. Powell, of Whitefriars Glass Works. A is a funnel with ground top, to which a glass plate, B, acts as a cover. Prepared cotton-wool or glass-wool is packed tolerably firmly at C, and is then moistened with alcohol (·820). The collodion is introduced into the funnel, and is allowed to filter through the plug into a bottle beneath.

Sensitising the Plates.—The glass plate having been coated, the next operation is to sensitise the film by converting the soluble bromo-iodide into silver bromo-iodide. Most foreign photographers employ a horizontal tray to hold the sensitising solution, but it is not recommended, excepting for plates of very large size, in which case it is absolutely necessary to employ this form of aparatus. The usual form of holder used for holding the solution is the vertical dipping-bath, into which the plate is lowered by a dipper. The horizontal bath has the advantage of taking less solution to cover a plate, though this advantage is more than counterbalanced by the rapidity with which it becomes saturated with ether and alcohol.

The corner of the plate from which the collodion has been poured off should be allowed to remain downwards.* When placed on the dipper in this position, the plate should be *gradually lowered, without stoppage,* into the dipping-bath.

When once covered,† the plate may be gently moved up and down (and also horizontally, if the bath be large enough) till all repulsion of the aqueous for the alcoholic solution has disappeared. The effect of this repulsion is known by the bath solution collecting in tear-drops and rivulets on the surface of the film, and is technically called "greasiness." This operation

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* Some operators keep this corner upwards. This may cause a "curtain" of collodion at that part of the plate.

† In this manipulation great care should be taken that the plate is kept entirely covered by the bath solution during the first minute, otherwise the film may become unevenly sensitised at the upper end, presenting an appearance of watered silk.

probably takes two to four minutes in cold, and only one and a half in warm weather.

When this motion is not given to the plate in the bath, the alcohol often collects in permanent rivulets on the surface of the film, preventing the access of the sensitising solution to the bromo-iodides beneath them. When, finally, the alcohol has become dissolved in the water, the beds of these rivulets would probably be less dense than those portions which had access at once to the bath solution, and the result would be the production of a streaky negative. By washing off the alcohol as described, no rivulets can collect; the film must become evenly sensitised, even before the total "greasiness" has disappeared.

When the greasiness can no longer be traced, the plate should be allowed to remain at rest for another minute and a half to three minutes, when, after a few more vertical motions in the bath, it may be taken out.

This last operation is generally performed in a hurried manner. Were more thought ordinarily exercised over every operation, many vexatious failures and much loss of time would often be avoided. A very little reflection must point out the utility of abstracting the plate *very* slowly. The capillary attraction of the liquid in the bath for the liquid on the plate will, if time be given, almost prevent the necessity of draining. The advantage of this force of nature is entirely lost by a rapid removal of the plate.

In taking the plate out of the bath-holder, the dipper holding the plate should be very slowly raised till a corner of the glass can be seized by the fingers of the disengaged hand. The top edge of the plate should be forced away from the dipper (if it be not made of silver wire), in order to prevent an accumulation of bath solution between these two surfaces, and the plate is then raised till it is clear of the solution, when it is immediately turned to the position it is to occupy in the dark slide. When a horizontal bath is used, all the solution is tilted to one side of the dish, the plate laid flat on the uncovered portion; the solution is then made to pass over the plate with one continuous wave, and it is rocked till all greasiness has disappeared.

It will be remarked that different lengths of time for sensitising are given below, to understand the reason of which the nature of the sensitiser, the proportion of iodide to bromide in the collodion, the strength of the bath solution, and the temperature must be considered.

1st. With a strong bath solution, a less time is required for fully sensitising the film than with a weak one.

2nd. The greater the amount of bromide in the collodion, the longer the operation will take, as the formation of silver bromide is much less rapid than that of the silver iodide; in fact, all the silver iodide has to be formed before any silver bromide is formed.

3rd. The colder the weather, the longer will be the time of immersion, as cold renders the access of the bath solution to the film more difficult.

A general rule as to the length of time required for sensitising ordinary commercial collodion is to immerse the plate three minutes in summer and six in winter.

Before work is commenced, the bath solution should be freed from any deposit there may be at the bottom of the bottle. Filtration should not be resorted to more than is absolutely necessary. When filtration is resorted to, the honey-combed side of the filter paper should be next the funnel, and it should be moistened with distilled water before the solution is run through. This may at first cause a slight emulsion of silver iodide, since this compound is less soluble in a weak solution of silver nitrate than in a strong solution, and the water in the filter paper naturally reduces the strength of the first portion of the bath. The turbid solution should be returned to the funnel, when it will filter through nearly clear. Some filter papers contain contamination which is injurious to the bath, and should be tested. Decantation of the clear liquid from the sediment should first take place, and then the remainder (containing the deposit) may be filtered if required.

Manipulations after Sensitising the Plate and before Development.—After the plate has been slowly withdrawn from the bath, it should be carefully drained on a pad of blotting-paper (three or four thicknesses at the least should be used), the end that is to be lowest in the dark slide being pressed down on to the pad; this prevents an accumulation of bath solution at the edge, and its consequent liability to cause stains.

The dark slide should be opened at the back, and held nearly vertical, and the plate put upon the silver wires after the drainings from former plates have been removed by blotting-paper. This vertical position is one which in practice is often neglected, but is of great importance, since any silver solution which may have collected, notwithstanding proper draining of the plate, is thus prevented from running over the surface, and causing markings.

The back of the plate should then be carefully wiped with a pledget of blotting-paper or rag, to remove any silver nitrate solution which may have collected on the back. Should this precaution be neglected, horse-shoe markings (see "Defects in Wet-Plate Negatives") on the developed image may be expected if the film be translucent.

Should the exposure be of considerable duration, or if the time between placing the plate in the dark slide and development be likely to be long, a moistened sheet of blotting-paper should be placed at the back of the plate. This will keep the film moist through the evaporation of the water, and if the blotting-paper be red, in a measure it will prevent halation or blurring of the image.

Finally, a strip of blotting-paper should be placed at the lower edge of the plate, and just in contact with the film, in order to prevent any accumulation of the bath solution during exposure. The practice of letting the blotting-paper come between the film and the silver wires which hold the plate in position is to be condemned, since the inner surface of the silver wires is made to coincide accurately with the surface of the ground glass; hence if the film do not touch them, the focus of the picture is altered, which may be of consequence with a short-focus lens.

The slide should then be closed, wrapped round with a cloth, and carried carefully in the same relative position as regards top as it will occupy in the camera during exposure.

The view should, of course, have been previously focussed on the ground glass of the camera.

The same precautions in carrying the dark slide to the developing room or dark tent should be observed as those already given for carrying it to the camera.

Development.—Having filtered the developer, if requisite, and placed the necessary quantity in the clean developing cup, the plate should be taken out of the slide, and kept inclined in the same direction as that in which it has been carried from the camera, though the angle of inclination may be much modified. The *developer is then, with an even motion and without stoppage* (the rim of the cup almost touching the film), swept over the plate till the latter is completely covered. As little of the solution as possible should be allowed to flow over the edges.

The writer prefers to keep the long edge of the plate next to him, whilst the corner of the plate where any drainage may have accumulated is away from him. The plate is held with a *small* inclination downwards away from the body, and then the developer is applied as above.

The developer is worked round and round to each corner of the plate in succession till the image is fairly out, which, if properly exposed, will take some minutes to effect. The deepest shadows alone should remain of the yellow tint due to the unaltered silver iodide and bromide. An under-exposed picture will take longer to bring out, whilst one over-exposed will flash out at once, and, unless the developer be immediately washed off, will appear to fade away and give a flat and fogged negative.

A properly exposed and developed picture should, by reflected light ("looking down on the plate"), appear as a well-defined and graduated image lying on a ground of silver bromoiodide; whilst by transmitted light ("looking through the plate") every detail should be visible both in shadow and high-light. With proper exposure the developer may remain on the film for a long time without injury to the image.

A plate-holder * is recommended for holding the plate during development. If not at hand, the corner must be held as described in the article on "Coating the Plate" (page 237); or else the plate may be supported in the centre by the tips of the fingers, though this is not recommended, as the warmth of the fingers, communicating itself to the glass, is apt to cause uneven development at those places. In developing large plates without the aid of a plate-holder, a support similar to that described at page 238 may be employed.

Some skilful photographers develop their pictures in a tray

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* Not that one which has been employed for holding the plate during coating collodion.

slightly larger than the plate. The plate is carefully placed at the bottom, and the developer allowed to flow over it in one unbroken wave. The development of the image is watched through the bottom of the dish if it be of glass.

The following maxims are worthy of attention :—

1st. Always have a weak and a strong developer in the field and in the dark-room.

2nd. Think well as to which will answer your purpose the better, remembering that with a strong developer contrasts of light and shade are subdued, while with a weak one they are increased.

3rd. Use your developer before it attains the dark reddish-brown colour, and do not use methylated in place of pure spirits of wine.

4th. The less acetic acid used, the more harmonious will be the resulting picture.

5th. Reject a negative which is either under-exposed or much over-exposed.*

Intensification.—Practice alone can give the operator a knowledge of the exact amount of density required in a negative. Pictures are often spoilt by bringing up the half-tones to a density nearly equal to that of the highest lights. It should be recollected that the printing power of a negative not only depends upon the quantity of deposited silver, but also upon its *colour*. If a negative, on account of its density and *colour of deposit*, allow the *deepest shadows* to print to a depth verging on bronzing, and at the same time leave the *highest lights* white, or very nearly so, any further intensification will be detrimental.

The operator's judgment must decide whether he should use those intensifiers which cause increased deposit, or those which merely cause change of colour. The latter are best avoided, except under exceptional circumstances, or where an engraving or similar subject is being copied.

Should the former be decided upon, and if the picture has been slightly over-exposed, it is well to stop all further danger of development by treating it with a weak solution of potas-

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* It is too often the case that time is wasted in attempting to patch up a worthless negative. If the image appears unsatisfactory, and it be possible to expose another plate, obey Rule 5.

sium iodide and bromide for a minute or two. This will completely check all further action, excepting that of intensification. A more common method of treatment is to fix the picture first, and intensify afterwards.

Intensification before fixing should be conducted as laid down for development. The intensifier should first be flowed over the plate, next the silver nitrate dropped into the cup, and then the intensifier from off the plate poured back. By this means a perfect mixture of the two is obtained. The intensification should proceed till the requisite density is arrived at, or till the solution becomes turbid if it be of iron, or deep brown if of pyrogallic acid. In the latter case a fresh portion should be taken, and the intensification proceeded with till complete.

When intensifying with pyrogallic acid, it will be found advantageous (*should the exhausted solution not be turbid*) to leave a little brown solution in the cup, and then to add a fresh portion to it. A more even and satisfactory action seems to be set up by this artifice.

In landscapes and in portraits, the highest points of light alone should appear opaque before fixing.

If it be necessary to obtain more photographic opacity after fixing, it is advisable to use the iodine solution first (No. 4, page 229).* This tends to prevent a red deposit forming on the shadows when the iron or pyrogallic acid formulæ are used. Intensification after fixing may be conducted in diffused light. It is more difficult to decide on the printing qualities of a negative which is intensified by change of colour. Practice alone can enable the operator to be sure that he has obtained the necessary opacity to the actinic ray.

Fixing the Negative.—For sodium hyposulphite, a dipping bath or shallow, flat dish may conveniently be used, or the solution may be flowed over the plate; if potassium cyanide be used, the latter mode of applying the fixing agent is advisable, and care should be taken to wash the plate directly all the silver iodide and bromide is dissolved away. The absence of these salts may be known by reversing the plate, and noting if

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* If the negative has dried before it is intensified, the edges should be varnished with Bates' Black Varnish, or run round with india-rubber solution, to prevent the film leaving the plate.

the yellow, semi-opaque colour has totally disappeared from the shadows.

After *development*, *intensification*, and *fixing*, the plate should be *well washed.*

Drying and Varnishing the Negative.—The plate may be allowed to dry either entirely spontaneously, or else by the application of heat. Quick drying, as before stated, gives an increased density to the image; if, then, part of a negative be allowed to dry spontaneously, and part by the aid of heat, the negative will not retain its proper relative gradation.

A neat appearance is given a negative when dry, and before varnishing, by scraping of the film round each edge of the plate to a distance of about one-eighth of an inch. This also prevents damp penetrating between the film and the glass plate, as the varnish coats both the margin and the film. Some photographers, after varnishing, run a line of Brunswick black one-eighth of an inch .wide along the edge of the plate; this gives a white margin to the prints, and gives them a neat appearance.

Before applying spirit varnish (see page 232), the plate should be warmed.* The varnish should be poured over the film like collodion over a plate, the same gentle rocking motion being given it whilst the excess is draining off. Any varnish collected at the lower edges may be removed by pressing them down on a pad of blotting-paper, after which the plate should be thoroughly heated. When cold it is ready for the printing operations.

A good source of heat is a moderator or paraffin lamp, the plate being moved briskly over the top of the chimney; another is an ordinary fire, or a Bunsen burner with a rose; and the worst, the flame of a spirit lamp. In using this last, great care is requisite to prevent the flame setting fire to the solvent of the varnish.

It sometimes happens that the film tends to peel off and split whilst drying. The application of stale beer to the negative will prevent this fault. A weak solution of gum has been

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* The soft part of the back of the hand, between thumb and first finger, should just be able to bear the heat of the plate. Amber varnish is applied cold.

recommended, but gum has the property of absorbing moisture; it swells, and causes the film to crack, the varnish being unyielding. Gum should, therefore, not be used, unless the negative is required to last but for a short time. The white of one egg mixed with ten ounces of water is recommended as being the safest material to employ.

CHAPTER XXV

DEFECTS IN WET-PLATE NEGATIVES, ETC.

In the foregoing chapter the bare manipulations necessary for taking a wet-plate negative have been discussed, and very little notice has been taken of the defects that are likely to be met with in the various stages of operating. This chapter will be devoted chiefly to a narrative of the defects, and the remedies to be applied.

Defects caused by the Glass Plates.—If the negative, after development, appears to be fogged in certain places, while the remaining portions are bright, a dirty (*i. e.* not chemically clean) plate may be suspected. If patches of the film are wanting in optical contact with the plate, as shown by the appearance of the same when looking at the reverse surface of the film, the suspicion is confirmed.* The dirt may arise from the improper cleaning of the plate with the tripoli powder or whitening (see page 214), or else from compounds unattacked by these detergents, such as the remains of corrosive sublimate (mercuric chloride) used in the intensification of a previous negative on the same plate.

The remedy in the first case is apparent; in the last case the plate should be washed well with water, and then steeped in nitric acid and hot water (one ounce to the quart is sufficient), and allowed to soak for twenty-four hours. This will probably cure the evil, after the plate has been thoroughly rinsed with cold water, and cleaned in the ordinary manner. Sulphuric acid and potassium bichromate, or a solution of cyanide, have been recommended. Practically they do not

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* An iridescent film should always be looked on with suspicion. They frequently split on drying, and are not in optical contact with the glass.

appear to have any advantage over the nitric acid. Should this treatment fail, the plate may be coated with a solution of albumen, as described hereafter.

Circular and straight transparent markings are sometimes met with when a negative has been taken on a plate that has been put away as clean. Their occurrence leads to the suspicion that the plate has since become damp, or that a damp silk handkerchief or chamois leather has been used in polishing, or, perhaps, that one has been used which has been washed with soap, and has not been thoroughly rinsed afterwards.

Sometimes the collodion sets in streaks from one corner or edge, forming large ridges and furrows on the plate, which become only too apparent on sensitising. Chips in the edges of the plates will cause this defect. The collodion clings to inequalities, and by molecular attraction small pools are formed, which finally run over on the plate, and cause ridges. The remedy for this defect is to re-grind the edges of the plate carefully, or, if only one edge be defective, to pour off the collodion towards that edge.

Opaque streaks in a negative are usually due to scratches in the surface of the plate. There is no cure for this defect—the plate must be rejected. If round, transparent markings of the size of a pin's head be apparent in the negative, when the glasses employed are new, a crystalline deposit on the surface of the plate must be looked for.

Defects caused by the Collodion.—When the plate is taken out of the bath, should the film appear much less opaque at the end at which the collodion was poured on than at the lower end *—1st, either the collodion has been allowed to set too long; 2nd, it has been prepared with too highly-rectified solvents, and ether in excess; or, 3rd, there is alcohol in excess, causing the plate to dry at the top before it has set at the bottom.

The remedies for the first cause are apparent; for the second, the bottle of collodion may be left unstoppered till the necessary amount of ether has evaporated, making up the quantity with alcohol, and then adding one or two drops of

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* The portion of the image developed on these semi-transparent parts would be very feeble.

water to the ounce; for the third, the addition of a drachm of ether and a quarter of a grain of iodide of cadmium to the ounce of collodion will prove effectual.

The sensitised film may show opaque markings at the corner whence the collodion was poured off. This is called "bursting out" of the silver iodide and bromide, the reason of its occurrence being that the film is not porous enough to hold them in the film. This "bursting out" may therefore be caused by too much iodide and bromide in the collodion, in which case plain collodion should be added; or it may be caused by the collodion being too alcoholic. If the film be allowed to set well before immersion in the bath, it is probable that the fault due to the last cause will be corrected.

Should the defect noticed in the last paragraph be exaggerated, shown by the iodide almost completely leaving the film in places, the collodion is either not sufficiently porous, or else has been too highly iodised. In the former case, water may be added little by little, and in the latter, plain collodion.

A film sometimes refuses to "work," though it may appear dense and creamy. The finger should be rubbed lightly along one corner of it, and if the silver bromo-iodide rub off, both the above remedies may be applied, since it is evident the salt is only surface-formed.

When a portion of the film leaves the plate with the bromo iodide, it has not been allowed to set sufficiently before immersion in the bath; the water in the bath acts on the pyroxyline before it becomes gelatinous (from the evaporation of the ether and part of the alcohol), and the cotton is precipitated.

Curtains on the film have been noticed in "Coating the Plate" (page 237), and the reason there given of their existence. The cure was also suggested.

Markings in the film having the appearance of a fine network or crape arise from the use of too gelatinous a sample of collodion, or from a strong cadmium * bromo-iodiser. The remedy, in the former case (in which the plain collodion *per se* gives this structure), is to add a more limpid sample to it. If caused alone by the latter, keeping will probably rectify the evil; whilst if the result be from both causes, the addition of

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* Solvents too largely diluted with water may also cause this defect.

a limpid collodion iodised with an iodide of an alkali, such as ammonium iodide, is recommended.

Should the developed image appear weak, and the film be opalescent, it is probable, if the collodion be in fault, that it is deficient in pyroxyline, either from sufficient not having been employed at first, or from a deterioration due to age.

A lack of half-tones in the image may be due to the use of a collodion whose pyroxyline has been made at too high a temperature, or by the iodine in it being liberated to excess, as shown by the deep colour it assumes. The defect suggests the cure.

Should the film split on drying, it is probable that the collodion used contained too much ether. Pyroxyline made with too strong acids will also cause the evil. Mixing with another sample of collodion will probably be the best cure. If the pyroxyline be made in weak acids, the film will generally adhere to the plate; but if it be of a gelatinous kind, it may leave it.

An under-iodised collodion will cause the developed image to appear flat and lacking in density. Try adding an extra grain of iodide of cadmium to the ounce. If the collodion be too highly bromised, and remain in the bath but a short time, the same defect will occur.

Opaque, comet-like spots are sometimes to be met with in the developed picture. They usually arise from dust in the collodion, due to small particles of undissolved pyroxyline. The best remedy is to have a stock-bottle for the collodion, and allow it to stand perfectly quiet. The upper portion may then be syphoned off and filtered (page 238).

Defects caused by the Sensitising Bath.—A line across a plate, seen after sensitising, denotes a stoppage in the motion of immersion.

Lines in the direction of the dip are generally caused by the bath being too alcoholic. (Each time a plate is immersed, the water absorbs a percentage of ether and alcohol.) The excess may be removed by raising the temperature of the solution to about 200° (98° C.) for half-an-hour to an hour. Most of the alcohol is driven off in vapour at that temperature, whilst the aqueous solution remains behind. The solution may also be boiled down to half its original bulk, and be made up to the proper strength by the addition of purified water. These lines may also occur through the use of collodion, which gives a very repellent film. This may be remedied by shaking it up with sodium carbonate, and decanting from the residue, or by adding to it one or two drops of water. Too great a quantity of alcohol in the bath, as is the case when many plates have been dipped in it, will also give a repellent film.

A scum on the film may be caused by the use of the bath containing too much silver nitrate. Test the strength of the bath solution, and add water, if requisite, filtering out any iodide that may be precipitated. A scum may also be due to the use of a collodion too highly bromo-iodised; if this be the case, the latter should be mixed with a small quantity of plain collodion. Silver acetate is likewise a form of scum, which often may be seen floating on the surface of the solution. It should in all cases be filtered out, or be removed by drawing a strip of clean blotting-paper along the surface of the bath solution.

A bath carefully used will rarely get out of order. Sometimes, however, by accident, it may become contaminated by foreign matter, and then the negatives will be poor, flat, or, in some cases, useless, through fog on the shadows. To render the bath fit for work, resort should be had to the action of sunlight on it; after neutralising the acid with sodium carbonate or freshly-precipitated silver oxide, sufficient carbonate is added to give a slight precipitate, or silver oxide is added till some remains undissolved. The bath is then placed in full sunlight, when all organic matter will be decomposed, and metallic silver deposited by it. This is the best and, probably, the only legitimate cure for a bath that gives negatives of the foregoing description, except evaporating the solution to dryness, and fusing the silver nitrate. The addition of potassium permanganate has also been recommended. It is at the best a doubtful cure.*

Should these means fail, the best plan to adopt is to precipitate the silver, and make a new bath from it.

There may be another cause of flatness in a negative—viz. the bath being below its proper strength in silver nitrate.†

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* Permanganate, fifteen grains (34 *grms. to litre*); water, one ounce. This solution to be added to the bath till a faint permanent pink colour is given.

† A method of testing the strength of the bath is given in the Appendix.

Transparent pinholes on a negative after fixing are caused either by dust, or through the bath being over- or under-iodised. Should they be caused by the bath being over-iodised, a granular appearance will be visible on the surface of the plate by reflected light. The granules of silver iodide* separated from the bath. The remedy for this is to take one-fourth of the bath solution and dilute it with three times its bulk of water. This will cause an emulsion of iodide, which can be filtered out. The solution can then be made of proper strength, either by boiling down, or by the addition of fresh crystals of silver nitrate. Another method is to add a few drops of hydrochloric (muriatic) acid to the solution with constant agitation. This carries down the excess of iodide along with the chloride, but leaves the bath acid, from liberation of nitric acid. The addition of barium nitrate has also been recommended as a permanent cure for over-iodising. In the experience of many operators it answers admirably. It has one defect, however, which is, that ferrous sulphate precipitates the barium as insoluble sulphate, which gives a slight veil over the image; but varnishing in a great measure restores the transparency. The following solution is recommended:—

Bath solution...	... 1 ounce ...	... 440 *parts*
Barium nitrate	5 to 10 grains ...	5 *to* 10 ,,

If necessary, the bath should be filtered after the addition of the barium salt is made. If the plate, after fixing, show signs of pinholes, without the excrescences being previously visible, the bath is under-iodised. In this case more potassium iodide should be added.

Markings showing unequal density at its lower end may arise from the plate not being properly drained; or, if properly drained, from the dark slide being reversed from its proper position whilst carrying it.

When the bath is very acid, hard negatives, wanting in detail, often result. The acidity may arise from the use of collodion which has liberated iodine, and acidified the bath solu-

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* This is rather a debatable point. Some attribute them to silver sulphate, oxalate, or iodo-nitrate. The writer prefers leaving the paragraph as originally given.

tion.* This may be remedied by adding an alkaline solution to the bath. Hardness may also be due to the development (see page 228).

Transparent flashes and curtains are generally caused by the free silver nitrate drying on portions of the plate, owing to the length of time elapsing between taking the plate out of the bath and developing it. Negatives are particularly liable to this defect if the baths be at all old and alcoholic. Careful draining, placing damp blotting-paper at the back of the plate in the slide, and other obvious precautions should be taken.

Opaque markings, taking the form of lines, may occur through the bath solution collecting and running down the plate, particularly if the plate be not fully sensitised. The rivulets of bath solution complete the sensitising of the plates in those portions alone, hence the image is stronger at those parts. The remedy is obvious.

Horseshoe markings, of about the size of a small pearl button, may occasionally be met with when a collodion is used which appears opalescent after sensitising. They arise from the reflections from the small drops of bath solution that accumulate on the *back* of the plate. It is needless to enter into the exact cause of the horseshoe form; but it can be rigorously demonstrated as resulting from the shape and motion of the drops. By carefully wiping the back of the plate before placing it in the slide this trouble will cease.

Defects caused by Development.—Lines may occur on the negative by the stoppage of the developer when poured over the exposed plate. The stoppage is generally the result of carelessness, but it sometimes may be due to drying of the film after removal from the bath, in which case more than ordinary of the developer must be taken to enable the plate to be properly flooded. The free silver nitrate having partially dried on the film, but little will be carried away by the developer. The defect may also arise from the repulsion between the free silver nitrate on the film and the developer, either through excess or defect of alcohol.

Lines may also be caused by leaving a small quantity of water in the developing cup, which will not readily mix with

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* The iodine liberated combines with the nitrate of silver to form iodide of silver, and liberates, together with other products, nitric acid.

the alcoholic developer, thus causing development to be delayed on those portions of the negative with which it happens to come in contact.

A poor and flat image may arise from washing off the free silver nitrate from the plate by the developer; from the use of too strong a developer; from the bath or collodion as explained in the two previous articles; or from over-exposure.

In addition to negatives becoming hard from faults in the collodion or bath, they may have the same defect from being developed with a weak developer, from one with too much acid in it, or from under-exposure. The first two causes may arise from the ferrous sulphate having changed to the ferric state, as explained at page 228.

A scum forming on the developer during development may denote a want of acetic acid in the developer.

Defects caused by Intensifying and Fixing.—The chief defects that arise through intensifying are those which may also occur in development. Fog and a red deposit on the shadows are chiefly to be anticipated. The former may occur before fixing if the pictures be over-exposed; the latter, both before and after fixing, by the addition of too much free nitrate of silver to the intensifier; or again, after fixing, by the imperfect washing of the film before the intensifier is applied. The red stain will generally yield to

Glacial acetic acid	1 part
Water	1 ,,

Fog may be reduced as given in the next chapter.

It should be noted that the larger the amount of silver added, the more rapid will be the intensification; but the half-tones will not be brought up proportionately to the high-lights. The smaller the quantity of silver used, the greater will be the comparative force given to them, and the longer time it will take to get proper printing density. Thus, a negative lacking in contrast may be corrected by using an intensifier with large, and one too rich in contrast with small, doses of silver.

Defects caused by Fixing are few in number; the chief is that caused by the potassium cyanide eating away the half-tones, through the washing being too long delayed. If strong cyanide be used, and it be allowed to stop in its flow over the plate, a line of weak density may become apparent. A film splitting after varnishing may often be traced to the use of sodium hyposulphite as a fixing agent, followed by an imperfect washing.

Defects caused by Varnishing.—Several defects may arise in varnishing. First, the most serious, the collodion film may dissolve away. This is caused by the solvent used in the varnish being impure and of a low specific gravity. The addition of a small quantity of water may effect a cure, or varnishing the plate cold, and *then* heating it, may answer in some cases.

Should a transparent mark show across a negative immediately after varnishing, it is probable that the solvents are *slightly* too strong, and that the varnish has not been allowed to flow over the film without stoppage. The cure suggests itself.

Ridges in the varnish on the film *may* denote that too much of the solvent has been allowed to evaporate by repeated applications to other plates; in which case add more spirits of wine (·830 methylated will answer). Ridges may also arise through rough edges of the plate, or from dust on the film. Varnish may crack through swelling after it has been applied to the film, and give blisters; or it may do so through the use of bleached lac.

If from any cause it should be desired to remove the varnish from a film, it should be subjected to the vapour of alcohol; or weak alcohol may be flowed over the plate five or six times, warming the plate as if for varnishing between each application. A solution of caustic potash will also be effectual, and leave the image in its original state, after which it may be re-varnished. Varnish may also contract; this is probably through the use of copal in its composition. Should the varnish dry matt, it is probable that sufficient heat has not been applied after coating the film with it. If it dry matt in parts, it is probable that the preliminary coating of the negative has been unequal.

Other small defects may sometimes be noticed. A little thought will generally trace their cause, and suggest the remedies.

Defects caused by the Dark Slide.—Should it happen that at one or more corners of the plate the silver is reduced on development, so as to cause opaque marks, the slide should be examined. The evil may arise through the wires which support the plate not being made of *pure* silver. A coating of varnish applied to them will prevent future mischief.

Opaque streaks seen after development, running from a corner, may denote the ingress of light into the slide, or they may be due to the fingers touching the film during development. Transparent marks of the size and shape of a pin's head, with a very small opaque dot in their centres, may show that dust has fallen from the front of the dark slide on to the film. The inside of the slide should be carefully wiped out with a damp cloth. Similar spots may arise from the use of collodion made with a pyroxyline which has been prepared with dilute acids (see page 217), though in this case the central dots are generally not visible.

Fog on Wet Plate Negatives.—Fog or veil over a negative being one of the commonest defects met with, it may be useful to point out the method to be adopted to detect its origin.

Over-exposure in the camera is one of the most common of its causes, particularly when working with newly-iodised collodion.

The contamination of the silver nitrate bath with organic or foreign matter may also give rise to it. It is easy to account for foreign matter in the bath, the dust and other impurities that float in the atmosphere of the dark-room being one source. Distilled water may also contain it, as ordinary stills are frequently used for distillation other than that of water. A bath made of impure gutta-percha* may also account for its presence, as will the wooden case of a glass bath, if the bath solution happens to touch the wood whilst being poured in or out. In all these cases sunning the bath solution, or evaporating it down to dryness, are the most effectual remedies. Potassium permanganate may be employed as a corrective, but, as before stated, is not recommended.

Alkalinity of the bath by silver oxide, which is slightly soluble in water, will be certain to cause fog. The cure in

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* Gutta-percha is often adulterated with magnesium salts, etc.

both cases has been given, under the head of the "Sensitising Bath" (page 222).

Diffused light in the dark-room, in the camera, or a dirty lens, will cause a foggy picture.

Vapour of ammonia, the products of the combustion of coal gas, and sulphuretted hydrogen, are also inducive of fog. All these vapours may be detected by their smell.

The omission of the acetic acid in the developer (or the presence of too small a proportion) will cause the evil, as also a very high temperature in the dark-room. Many common sorts of filter paper contain iron and other impurities, which may induce fog.

Tracing the cause of Fog.—Should a negative appear fogged, another plate should be sensitised, and reduced exposure given it; if this fail to effect a mitigation of the evil, the bath should be tested for acidity or alkalinity, as shown at page 224. If the bath be of the right acidity, a plate should be sensitised and kept for two or three minutes in the dark-room. It should then be developed, and the presence of fog will indicate (supposing no hurtful vapours be present) either organic matter in the bath, or diffused light in the dark-room. Another plate, similarly treated in a really dark room, will show if it be due to the latter cause. If, however, it be proved that there is no filtration of light which can act on the silver bromo-iodide into the dark-room, another plate should be sensitised and placed in the camera. The front of the slides should be withdrawn as usual, but the cap of the lens should not be removed. The plate should next be flowed with the developer in an absolutely dark room. If fog be still apparent, the bath is at fault. If the bath be new, it may be that there are atmospheric impurities present which cause fog, or it may be due to alkalinity.

If neither the bath nor the atmosphere be at fault, and if fog be present, diffused light is admitted into the camera; if absent, it is probable that the fogged negative was due to the bad lighting of the subject, or to diffused light through the lens, as in the case in which the sun is allowed to shine directly on it, rendering the glasses slightly luminous.

CHAPTER XXVI

COLLODION DRY PLATE PROCESSES

THERE are manipulations common to all collodion dry plate processes, and it is proposed to detail them here, instead of repeating them with each process. 1st. The plate is cleaned. 2nd. It is given a substratum, or edging, to cause adhesion of the film during development. 3rd. The plate is coated with collodion, and sensitised; or it may be coated with collodion containing the sensitive salts in suspension. 4th. It is coated with a preservative after washing. 5th. It is dried. 6th. It is exposed. 7th. It is developed, toned, and varnished.

Edging the Plate, or giving it a Substratum.—A plate may be edged with albumen, gelatine, or india-rubber; or the surface may receive a fine coating of any of these bodies, in order to cause adhesion of the film to it during development and subsequent treatment. It is not always absolutely necessary, when working dry plates, to give either edging or substratum; but, as a rule, it is advisable.

When a substratum is to be given to the plates, they should not be polished by the silk handkerchief. It is better to soak them first in potash, then in a dilute solution of nitric acid, and finally to rinse them thoroughly in pure distilled water. They should then be placed in a rack on clean blotting-paper, and be allowed to dry spontaneously. If albumen be employed as the substratum, the following should be made up:—

Albumen ...	... 1 ounce (white of one egg)	1 *part*
Water ...	50 to 100 ounces ...	... 50 to 100 *parts*
Liquor ammonia ...	5 drops* ...	... ... *a trace*

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* Three or four drops of commercial carbolic acid may be substituted for the ammonia.

The albumen and water should be well shaken together in a bottle for five minutes, and then filtered through fine filter-paper or well-washed tow. The funnel should be lowered nearly to the bottom of the beaker into which the albumen is filtered, to prevent the formation of air-bubbles.

Another plan of preparing albumen for a substratum is due to Mr. Ackland, and described by Mr. Brooks.

The whites of fresh eggs are collected, and to every 8 ounces 1 ounce of water and 24 drops of glacial acetic acid are added, by pouring it into the albumen in a fine stream, and stirring evenly with a glass rod for one or two minutes. The albumen should on no account be beaten or whisked up, or the resulting preparation will be milky. It is allowed to rest one hour or more, and is then strained through coarse muslin or cheese cloth. To the strained albumen is added 1 drachm of the strongest liquid ammonia (·880), when it can be put away in corked bottles and kept for use.

To make a substratum, Mr. Brooks takes—

Prepared stock albumen	... 1 ounce	... 1 *part*
Water	... 1 pint	... 20 *parts*

A convenient method of applying albumen is that described by Mr. Valentine Blanchard. A brush is made of swansdown calico, as follows:—A strip of glass, about six inches long by two broad, should be procured, and round one end should be attached, by means of thread or by an india-rubber band, a double fold of swansdown calico. This brush should be dipped

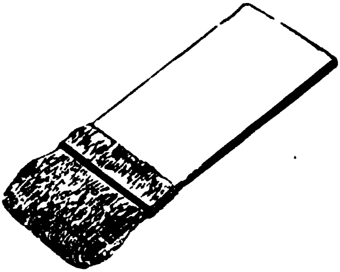

Fig. 138.

in the albumen, and the excess squeezed out against the beaker. The plate should then be brushed smoothly down the surface in parallel lines to within one-eighth of an inch of its edges, set up to dry on blotting-paper, and protected from dust. When dry (which it should be allowed to do spontaneously), the plate will be ready for the collodion.

Some prefer to flow the plate with the albumen solution. This is best done on a plate which has been well cleaned but not polished, and which has been subsequently moistened with distilled or rain water. Whilst still wet, the albumen should be flowed over the surface as in coating a plate with collodion, and the surplus fluid returned to the stock bottle through the filter.

Another albumen substratum which is very efficient for collodion emulsion and gelatine emulsion plates is as follows:—

Albumen (prepared as in the foregoing formula)	1 part
Water	20 parts
Silicate of soda (saturated solution) ...	1 part

These are mixed, and, after allowing any precipitate to settle, the solution is flowed over the plate. With this—as, indeed, with all substrata—the plates are freed from any tear-marking containing nuclei of dust, if they are dried off over a Bunsen burner or a hot fire. We prefer this last substratum for all processes in which the albumen is not coagulated by silver nitrate, as in all such (as in the washed collodion emulsion process) the albumen is apt to be washed off the plate when applying the preservative, and its application thus rendered nugatory.

Another substratum which gives even better results than the albumen by itself is the following:—

Sheet gelatine	... 75 grains ...	75 *parts*
Distilled water	... 60 ounces ...	26,400 ,,
Ammonia	... ¼ ounce ...	110 ,,

The gelatine should be first softened in half the cold water, and then dissolved by adding the remaining half in a boiling state. When cool, the ammonia should be added, and afterwards the solution should be filtered. It is advisable to make it up fresh as required. The addition of one ounce of alcohol has been recommended; the writer has failed to obtain any practical advantage by its employment. The substratum is applied as directed above.

Dr. Vogel gives another substratum, which is also efficacious, and easily applied :—

I.

Gelatine	50 grains ...	50 *parts*
Acetic acid	½ ounce ...	220 ,,

are placed in a bottle and warmed till solution takes place. This keeps a month.

II.

Chrome alum	10 grains ...	10 *parts*
Water	½ ounce ...	220 ,,

is next prepared.

Take of No. I.	2½ parts
No. II.	1 part
Methylated spirit	70 parts

and filter; coat the plates, after cleaning and drying, as with collodion, and allow the substratum to dry.

We have used a stronger solution, and found it also to give the required result :—

Gelatine	50 grains ...	5 *parts*
Acetic acid	½ ounce ...	22 ,,
Alcohol	¾ ,, ...	33 ,,
Chrome alum solution ...	1 drachm...	5·5 ,,

This is applied like collodion, and gives a beautifully bright, transparent film. It can be "dried off" against the fire, or over a Bunsen burner.

The formula for the india-rubber solution (which should be poured over the cleaned plate like collodion) is—

India-rubber	1 grain ...	1 *part*
Chloroform (commercial)...	1 ounce ...	440 *parts*

Or,

India-rubber	1 grain	1 *part*
Benzole (rectified)	1 ounce	440 *parts*

It will be remarked that all of these solutions are very dilute. If they were of greater strength, it would be found that they were excessively liable to cause blisters in the collodion film.

The Collodion for Bath Dry Plates.—The collodion to be recommended is such as will give by the wet process a brilliant and intense negative. The film should not be horny, whilst, on the other hand, it should not be of that character which admits of being easily torn. The writer has found that the addition of water to it causes a greater sensitiveness, doubtless owing to the porous state in which it is left. The following procedure may be adopted :—Take half the collodion to be used in dry-plate work, and drop into it distilled water to such an amount that on coating a plate the film appears slightly reticulated. The remaining half should then be mixed with it, and, as far as the physical nature of the collodion is concerned, it will be found in good condition.

It may be advisable to prepare collodion separate for some processes, and if so the pyroxyline should be prepared at high temperatures. This is specially the case with certain emulsion processes.

Sensitising the Plate.—The bath should be such as will give a good negative by the wet process. It should be of the strength of about 40 grains of silver nitrate to the ounce unless highly bromised collodion be employed, in which case it may be of the strength of from 60 to 80 grains to the ounce, and the plate should be kept in it for about ten minutes.

Washing the Sensitive Film.—After sensitising, it is necessary to eliminate the free silver nitrate from the film. The following method will be found efficient. Two flat dishes or dipping baths should be filled with distilled or purified water, and immediately after the plate is taken out of the bath it should be placed in one of them. It is of great consequence that the plate should be immersed in the water without stoppage. When using a flat dish, a certain knack is required to effect this. The most successful method is to hold the plate nearly touching the surface of the water, and then to allow the plate to sink by its own weight. With a little practice, an even, circular wave moves over the surface, and there will be a consequent freedom from markings due to this part of the preparation.

When the ether and alcohol have been absorbed by the first washing (which is known by the absence of all "greasy" appearance on the surface), the plate should be removed to the second dish or bath, and be allowed to remain at rest for four or five minutes.* It is then washed under the tap for a couple more, and finally rinsed with distilled water, when it will be ready for the preservative.

The Preservative and its Mode of Application.—At page 3 it was stated that a preservative was used to absorb the iodine and bromine liberated by the action of light from the silver iodide and bromide present in the film. It has other uses, however, the chief one being the prevention of the excess of the atmosphere to the sensitive salt. Without such protection the latent image would become oxidised, and, consequently, undevelopable. Let it here be remarked, that the presence of moisture is absolutely necessary in the preservative to ensure sensitiveness. A plate which is thoroughly desiccated is very insensitive. Hence, in dry climates, precautions of some kind must be taken to be certain of its presence. The preservative is usually applied by floating it on the surface for about a minute. It is a good plan to allow the solution from one plate to flow back into the cup, and to use it for the first flowing of the next plate, and then to apply fresh. By this means dilution from the water on the surface of the film is avoided. Some operators, in certain cases, apply the preservative by immersing the plate in a flat dish or dipping bath containing the solution. As a rule, this procedure is not to be recommended, as any contamination from one plate is liable to be carried on to another.

Drying the Plate.—After applying the preservative, the

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* If the plates are required to be kept but a short time (say three or four weeks), a minute's washing under the tap is sufficient. The plate will be rather more sensitive than if the washing be prolonged. In the case where the preservative is washed off, one minute's washing suffices.

plate is usually dried spontaneously, but sometimes by the aid of heat,* the temperature being maintained below 212° (100° *C.*).

To the photographer who works with home-made dry plates a perfect drying-box is a *sine quâ non.* It may be taken for granted that the larger the box the more even will be the drying of the plates, and consequently the better chance of perfection in the negative.

An ordinary cupboard † may be converted. The shelves at the back edge should be pierced with holes close together, or an interval left between them and the back of the cupboard. About two and a half inches from the back, small tumblers ‡ (such as described for developing cup) should be let into the shelf, the rim projecting about half-an-inch above the shelf itself. Small strips of glass should then be fastened round the cupboard, at such a height that when the corners of the plates which are to be dried rest in the tumblers, the opposite corners should rest against them. Ventilation should be secured by boring holes at the top and bottom, covering them with strips containing L-shaped holes. The accompanying diagram shows the form. A A, the top of the cupboard; B B, the strip of wood screwed on to cover the aperture O. The inside of the L-pieces and the side of O should be blackened, to prevent any reflection of light. If hot water or hot-air pipes can be passed through the cupboard, the rapidity of drying will be increased. In this case, over the pipes, and at a distance of six inches from them, should be placed a sheet of perforated zinc. This will equalise the distribution of the heat to a great extent.

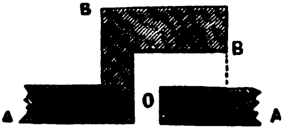

Fig. 139.

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* The plate should never be altered in position whilst drying, for if it be a mark is sure to appear round the portion only partially desiccated.

† For special drying-boxes, see Chapter on "Gelatine Emulsions."

‡ The small porcelain or glass ink pots used for school desks are equally good.

The temperature of the cupboard should be kept as even as possible, sudden changes being detrimental—producing markings. Opening the drying cupboard door before the plates are dry, when once the gas has been turned on, is a mistake; the plates should be left until it is judged they are quite dry. Very quick drying is a mistake, both for collodion and also for gelatine plates.

When collodion dry plates are to be dried, the wires or slabs are best removed, and little movable shelves fitted round, in which the small tumblers are placed as above.

Backing the Plate.—With some kinds of plates, more particularly if a gum or albumen preservative be used, the films are very translucent, and the image is subject to halation (see Chapter VI.). This defect is in a measure cured by applying some non-actinic varnish to the back of the plate. This backing may be made as follows:—

Powdered burnt sienna ...	1 ounce ...	1 *part*
Gum	1 ,, ...	1 ,,
Glycerine	2 drachms...	¼ ,,
Water	10 ounces ...	10 *parts*

The solution can be brushed on with a hog's bristle brush. Ordinary printers' paper, coated with gum-arabic, stained with aurine or a blue absorbent dye, and fastened on the plate, is as clean a method of backing a plate as can be desired. Whichever backing is employed, it should be removed previous to the development of the plate, and it is often convenient to do so after the alcohol has been applied to the surface of the film, and before washing with water. The alcohol repels any water containing the soluble part of the backing, and thus prevents staining of the image. A small tuft of cotton-wool will remove the backing given above.

Collodion stained with aurine may also be used, but with collodion plates this is somewhat difficult. The most perfect backing is a thin solution of asphaltum in benzole. This must be applied to back of the plate when dry.

Packing Plates.—To pack collodion dry plates, resort must be had to any of the methods given for packing gelatine plates (Chapter XII.), in which the films are not placed in contact with the paper or with each other.

CHAPTER XXVII

DETAILS OF DRY PLATE PROCESSES WITH THE BATH

The Gum-Gallic Process.—This process was first introduced by Mr. R. Manners Gordon, and in his hands, and those of many photographers, has proved of great value. The negatives are possessed of remarkable delicacy, and have an appearance similar to wet plates. The plate should have a substratum (see page 260); an edging in the place of small plates suffices. After development, the film will probably blister if only an edging be given, and by soaking in water these blisters may be caused to join and give a loose film, under which will be a layer of water. The corner of the film should be pricked, and the water drained out.

To ordinary good collodion should be added one grain per ounce of cadmium bromide, and the plates kept in the bath for seven minutes in summer, and ten in winter, in order to convert the greater part of the bromide into the silver salt. They should be worked up and down in the solution till all greasiness has disappeared, and should then be left quiet till just before withdrawal.

After washing, the preservative is applied; it is made as follows:—

No 1.—	Gum-arabic	20 grains ...	20 *parts*
	Sugar-candy	5 " ...	5 "
	Water	6 drachms ...	330 "
No. 2.—	Gallic acid	3 grains ...	3 "
	Water	2 drachms ...	110 "

No. 2 is prepared with the aid of heat, and is then mixed with No. 1 in the proportions indicated.

The gum-arabic should be that known as "picked"; that is, all yellowish lumps should be rejected, nothing but the white being used.

The water used should be distilled, rain, or purified. If it contain iron in appreciable quantity, it is fatal to success.

To filter this solution, which contains gallic acid, great care should be taken to select a thin filtering paper which is free from iron. The presence of this impurity will be indicated by the solution turning an inky colour. The solution will be found to run through the paper better if kept warm.

A further aid to filtration will be given by the following contrivance, which, it may be noted, will serve to aid the filtration of most viscous bodies.

Fig. 140.

A cork or india-rubber stopper is pierced with two holes. Through one is passed a funnel containing a platinum foil support for the filter paper, and through the other a bent tube, as shown in the sketch. By means of india-rubber tubing, this last can be connected with either an exhaustive syringe, a Bunsen water-pump, or an aspirator of the usual form. Attaching a length of india-rubber tube to glass tube, closing one end by nipping with the fingers of one hand, and then drawing back the air which is in the tube by running the fingers of the other hand along it, is usually sufficient to exhaust. The partial vacuum thus made causes the solution to pass with tolerable facility through the filter paper. Another aid will be found described in the filtering of gelatine emulsions.

The preservative is applied by floating it on the surface for about one minute. The plate must then be allowed to drain, and finally be allowed to dry spontaneously in the drying-box. If the plate, previous to exposure, appear dull, it should be dried by artificial heat before being placed in the dark slide.

Exposures.—Great latitude in exposures is admissible; it should rarely be less than four times, nor more than twenty times, that which would be required for wet plates under ordinary circumstances; though with the alkaline developer the exposure may be reduced to that necessary for a wet plate. The acid iron developer yields splendid negatives and transparencies from a well-exposed and well-prepared plate.

To develop the image, the backing (if any) must first be entirely removed with a damp rag, or peeled off in the case of paper backing. The plate should then be immersed in a dish of water of not less than 65° Fah. (19° *C.*) for two or three minutes, to soften the gum, and be finally rinsed under the tap. The following developer should now be flowed over, and, if properly exposed, the image will begin to appear almost immediately :—

No. 1.—	Gelatine (any kind will answer)	64 grains	64 *parts*
	Glacial acetic acid	2 ounces	880 „
	Water	14 „	5960 „
No. 2.—	Ferrous sulphate	30 grains	30 „
	Water	1 ounce	440 „

Half the quantity of water in No. 1 should be taken, and the gelatine be allowed to soak till it be thoroughly swelled. The remaining half of the water should be added in a boiling condition, which will cause solution. The acetic acid should next be added, and the whole allowed to cool.

One part by measure of No. 1 should be mixed with three parts of No. 2, and then filtered. It is expedient to mix no more than is necessary for one or two days' use, as the iron undergoes oxidation. No. 1 will keep indefinitely, whilst No. 2 should be made as required.

To every drachm of developer used, one minim of a solution of silver nitrate (30 grains to the ounce, 1 *part to* 150 *parts*) should be added just previous to its application to the plate.

As the image appears, more silver solution must be added, by two or three drops at a time, till the whole of the detail is visible. The film must next be well washed, and intensity gained by the ordinary pyrogallic acid intensifier and silver solution (page 228). The negative should have all the characteristics of a wet plate, if properly manipulated. Should it be inferred that the plate is over-exposed, more of No. 1 may be added to the developer. It is important that the silver solution be added to the developer previous to flowing over the plate. If the latter be applied alone, and then silver be added, the resulting negative is liable to be granular in appearance.

Ferrous oxalate (see page 179) development may also be used most effectively. The mode of employing it is the same as given for collodion emulsions. It should be followed up by the ordinary intensifier, such as described at page 228.

Albumen Beer Process.—The following process was introduced by the writer for solar photography, and was employed in the English Transit of Venus Expedition for 1874. It is, however, equally adapted for landscape work, and is very certain in its results. The collodion employed can be that described at page 217, though for more rapid work the following is better :—

Alcohol (·825) ...	4½ to 3 drachms ...	240 *to* 160 *parts*
Ether	3½ to 5 „ ...	200 *to* 280 „
Pyroxyline ...	... 7 grains	7 „
Ammonium iodide	... 2 „	2 „
Cadmium bromide	... 5 „	5 „

The relative proportions of ether and alcohol are adjusted according to the temperature in which the plates have to be prepared.

With the ordinary samples of collodion, the usual 40-grain (1 *to* 11 *parts*) silver nitrate bath can be used, but with the collodion made as above it is advisable to use a bath made up to 60 grains (1 *to* 7 *parts*), preparing it as given at page 224. It has also been found advantageous to dip the plates in the weaker bath at first, allowing them to remain in it for a couple of minutes, and then to transfer them to the stronger bath for ten minutes more. This mode of procedure gives very sensitive and opaque films, the greater part of the actinic rays being thus utilised. The sensitiveness, however, greatly depends upon the porosity of the film, and every effort should be made to attain the maximum of this quality without injuring its texture. The addition of the largest practicable amount of water to the collodion tends to give this quality. After sensitising, the plate is slightly washed, and then the first preservative applied, which is—

Albumen	1 *part*
Water	1 „
Ammonia	$\frac{1}{8}$ „

This is beaten up into a froth (or is mixed by pounding it in a mortar with silica), and when settled the clear liquid is decanted off. This solution is mixed with equal quantities of any ordinary beer or stout immediately * before use, and is floated over the plate. (When bottled beer is used, it is advisable to drive off all the carbonic acid by a gentle heat.) The excess is drained off, and the film thoroughly washed under the tap for a couple of minutes, and is finally covered with a solution of plain beer, to every ounce of which two grains of pyrogallic acid have been added.

The plate is dried in the ordinary manner.

The exposure, with well-prepared dense plates, is at least as short as that necessary for wet plates, but great latitude is admissible. With twenty times the minimum exposure a good negative can be obtained. In very dry climates the sensitiveness rapidly diminishes, owing to the water being completely eliminated, and this is a necessary part of any sensitiser when its full power is to be exhibited.

The development need not be effected for a month after exposure. The following solutions are required:—

No. 1.—Pyrogallic acid	12 grains	...	12 *parts*
Water	1 ounce	...	440 „
No. 2.—Liquor ammonia (.880) ...	1 part		
Water	4 parts		
No. 3.—Citric acid	60 grains	...	60 „
Acetic acid	30 minims	...	30 „
Water	1 ounce	...	440 „
No. 4.—Silver nitrate	20 grains	...	20 „
Water	1 ounce	...	440 „

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* This precaution is necessary, otherwise the tannin of the beer is precipitated by the albumen.

The washing water before development should be of a temperature not less than 60° Fah. When washed as directed the following developer is employed :—

To each half ounce (220 *parts*) of No. 1 are added three drops (3 *parts*) of No. 2, and, after well mixing with a stirring-rod, the solution is flowed over the plate.

Almost immediately the image begins to appear, and, after a few seconds' interval, the detail can be seen by reflected light to gradually develop. Another two drops (2 *parts*) of No. 2 are again added to the solution, which is once more flowed over the plate. Six drops (6 *parts*) of No. 3 are next dropped into the developing cup, and the solution from the plate poured on to it. Again the plate is rinsed, this time by the acid solution, and intensification is given by the use of it with a few drops of No. 4. It is not advisable to allow too much detail to come out with the alkaline solution, but to allow a portion of it to be brought out by the subsequent treatment with the pyrogallic acid and silver. The alkaline developer reduces the bromide salt, and leaves the iodide to be attacked by the silver solution. It will be remarked that no restrainer such as bromide is employed; the albumen dissolved by the ammonia plays the part of a retarder, but not as a destroyer of the latent image.

When the image appears sufficiently dense, it is fixed either by sodium hyposulphite or by potassium cyanide.

In other dry-plate processes where bromide must be used, the developer recommended for gelatine plates may be employed, using one-eighth the amount of ammonia solution, and double the bromide.

It should be remarked that where gelatine or albumen is employed as a preservative, bromide is not required, as they both act as physical restrainers to development.

Besides the defects that are common to both wet and dry plate processes, the following may be met with.

Blisters.—If blisters * make their appearance, it is probable, if the substratum be of albumen, that the solution is not sufficiently dilute. With some kinds of india-rubber blisters always appear.

Transparent markings may be caused by handling the plate

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* Warming the plate, and then cooling it just previous to coating with collodion, is of service, preventing blisters.

with warm fingers before immersion in water previous to development. The corners of the plate alone should be touched.

Large, opaque spots may be caused by allowing a warm finger to touch the plate during preparation or development.

A transparent edge will be caused by allowing the whole length of the edge of the plate to rest on blotting-paper when drying in the drying-box.

A lack of density is caused by the collodion being too thin, requiring more pyroxyline; by an insufficient quantity of bromide and iodide; by insufficient sensitising in the bath; or by too weak an alkaline developer.

Lines may be caused by a stoppage in the flow of the developing solution; by moving the plate in the drying-box previous to complete desiccation; or by an uneven flow of the preservative over the film.

Black spots on the film may be due to an india-rubber substratum, and to dust on the plate.

Transparent spots may be met with when photographing near the sea. They are probably due to the chloride of sodium which is held in suspension in the air. They rarely occur if the plate has been thoroughly dried by artificial heat a short time before exposure.

Pinholes may be caused by the solution of silver added to the developer dissolving out iodide from the film. If the preservative be not well filtered, such defect may likewise occur.

Black stains.—When ferrous oxalate development is used, black stains sometimes occur through handling the plate with fingers not absolutely free from sodium hyposulphite.

CHAPTER XXVIII

COLLODION EMULSION PROCESSES

THOUGH an emulsion of bromide of silver in collodion is easy to make, there are certain details to be attended to in order to secure success, and these depend upon a knowledge of the theoretical principles involved in the formation of the photograph and its subsequent development, for which see Chapter III.

Unwashed Collodion Emulsion Process.—The following will be found a good sample of an emulsion process. The plain collodion is made as follows:—

Alcohol ...	... 2½ ounces	... 1100 *parts*
Ether ...	... 5 ,,	... 2200 ,,
Pyroxyline ...	... 75 grains	... 75 ,,

It is proposed that eventually 200 grains (200 *parts*) of zinc bromide shall be dissolved in the collodion, or combined with silver nitrate in excess.

200 grains (200 *parts*) of the zinc salt are weighed out, dissolved in the smallest quantity possible of alcohol, and four or five drops (*parts*) of concentrated nitric acid are added to it in order to render any oxide or other impurity that may be present innocuous. This is then added to half the above collodion. We next require 300 grains (300 *parts*) of silver nitrate to saturate the zinc bromide, and to allow three grains (3 *parts*) in excess for each ounce of the concentrated collodion. As this will probably be about 11 ounces (4840 *parts*) by the time the additions are made, 330 grains (330 *parts*) of silver nitrate (which has been previously pounded up in an agate mortar, or the crystals of which have been crushed with a glass stopper on a thick glass plate) are weighed out. This amount

is then placed in a large test-tube, with 2 dr. (110 *parts*) of water, and warmed; a perfect solution ought to result. In another test-tube 1½ oz. (660 *parts*) of alcohol (·850) are boiled, and poured upon the dissolved silver. The two fluids may not mix at first, but by pouring them from one test-tube to another this is readily accomplished. This is added to the other half of the above quantity of collodion. Into this silver collodion the bromised collodion is added drop by drop with much shaking, or the silver collodion may be placed in a jar, and a stirring-rod used. In case this plan is adopted, the bottle containing the bromised collodion is taken in the left hand, and the stirring-rod in the right, and the bromide solution is poured drop by drop into the silver collodion, which is kept in brisk agitation by the glass rod. If the above details have been carefully carried out, the colour of a candle or gas-flame, when viewed through the liquid which runs down the inside of the glass jar, after agitation, should appear of a deep orange approaching to a ruby tint. It must be here noted, that with some pyroxyline it is absolutely impossible to obtain this ruby tint, no matter how carefully the mixing is done. With an unsuitable cotton it often assumes a grey or even blue form. The film in this case is often horny, and very transparent. When in the ruby condition, it may be judged that it has been rightly prepared. With the glass rod a drop or two of the emulsion should be dropped on to small strips of glass, and examined by daylight for structure, etc. When viewed through a window, the principal part of the light transmitted should be orange. A little potassium *chromate* should be dropped on to the emulsion on the plate, and a bright red colour will show that the silver is in excess, which is what is required in our case. If this colouration be absent, it will indicate that the soluble bromide is in excess, which, in some modifications of the same process, is what may be desired. The emulsion must next be decanted off into a bottle capable of containing at least double the amount of fluid —that is, at least twenty ounces (8800, say 10,000 *parts*)—and made up with equal parts of ether (·720) and alcohol (·850) to fifteen ounces (6600 *parts*), and it should then be shaken for ten minutes. It may now be put on one side for from sixteen to twenty-four hours, when it will be ready for coating plates.

The reason of keeping it is to produce a creamy film, dense and sensitive. If used at once the film would be apt to be insensitive, and be unsatisfactory. If kept longer than the above time, the bromide seems to change in character again, and to become less dense and less sensitive. The addition of a little soluble bromide—say 20 grains (20 *parts*) to the above quantity—and then 30 grains (30 *parts*) of silver nitrate, both in alcohol, will restore its sensitiveness.

The plate having been coated with a substratum or edged, the collodion (which should have been shaken about half-an-hour before it is to be used) is poured on it as collodion is in the wet process, and, when set, immersed in a dish of distilled or rain water. When all greasiness has disappeared, it is flooded with any of the preservatives given for dry plates prepared with the bath. Canon Beechey recommends the plate to be immersed in a dish containing beer to which one grain per ounce of pyrogallic acid (1 *to* 440 *parts*) has been added. The drying is conducted in the usual manner. The exposure may be taken to be about the same as that necessary to be given to a gum-gallic film. Between exposure and development the plates will keep fairly for a week, but after that seem to lose detail, and appear under-exposed. The following alkaline developer is used for developing these plates:—

No. 1.

Pyrogallic acid	6 grains ...	6 *parts*
Water	1 ounce ...	440 „

No. 2.

Potassium bromide ...	20 grains ...	20 *parts*
Water	1 ounce ...	440 „

No. 3.

Ammonia (·883)	1 *part*
Water	32 *parts*

Or,

Ammonium carbonate ...	80 grains ...	8 *parts*
Water (distilled) ...	1 ounce ...	44 „

To every two parts of Nos. 1 and 2, one part of No. 3 is added. It is well to flood the plate for a second or two with the mixture of Nos. 1 and 2 before adding No. 3. This prevents irregularity in development.

Another form of the *same developer* is as follows:—

No. 1.

Pyrogallic acid ...	... 96 grains	... 96 *parts*
Methylated alcohol	... 1 ounce	... 440 „

No. 2.

Potassium bromide	... 12 grains	... 12 *parts*
Water (distilled) ...	... 1 ounce	... 440 „

No. 3.

Liquor ammonia ...	... 25 minims	... 25 *parts*
Water	... 1 ounce	... 440 „

To develop the plate, take of—

No. 1	... 6 minims	... 6 *parts*
No. 2	... ½ drachm	... 27 „
(Half the quantity in cold water.)		
No. 3	... 3 drachms	.. 165 „

The developing solutions, made according to either formula, should be mixed immediately before use, and, after well stirring with a glass rod, be flowed over the plate. When the detail begins to appear, the bulk of the solution should be poured back into the developing glass, and the appearance of the image watched. If the detail appear slowly and regularly, the developer should be again flowed on the plate, and the image be allowed to gain full density. If, however, it appear very slowly, and with apparent difficulty, another drachm of No. 3 should be added to the solution in the glass, and again be applied to the film. If the detail flash out at once, the action must be instantly checked by water, and another half drachm of No. 2 be added to the developing solution, which should be again applied.

Should the preservative on the plate be soluble in alcohol, then that solvent should first be applied to the plate (edged round with india-rubber, if necessary), and then be washed till all the alcohol has been removed. It is very convenient to develop these plates on a levelling stand, in which case an india-rubber edging given to the film is a great help to keeping the solution on the plates.

Sufficient intensity is not always gained by alkaline development, but the plates may also be developed with the ferrous-oxalate developer (page 179), using, to every part of it, an equal part of a 5 per cent. solution of potassium bromide, by which a great density can often be obtained. If still deficient, the ordinary intensifier (page 228) should be applied afterwards. It is not always easy to secure sufficient density with emulsion plates, even by the application of silver and pyrogallic acid. In this case, after fixing, the image may be converted into iodide of silver by the iodine solution (page 229), be washed, flooded with a weak solution of silver, be exposed momentarily to light, and be then intensified by iron or pyrogallic acid (page 228).

The plates are fixed with potassium cyanide or sodium hyposulphite (see page 231).

If it be desired to make an emulsion with excess of bromide, the silver employed should be reduced to 280 grains (280 *parts*), and the above directions followed, omitting the nitric acid from the zinc bromide.

Washed Emulsion Process.—When to a soluble bromide in collodion, silver nitrate has been added, and an emulsion of silver bromide formed, there remains, as the result of the reaction, nitrate held in solution, or perhaps in minute suspension.* If the emulsified collodion were applied to a plate, and allowed to dry in this state, there would be a crystallisation of these nitrates, and unless they were removed the film would be in an unsatisfactory state for developing the image. Washing the film, of course, effects this; but it is most convenient to wash the emulsion itself.

To make such an emulsion, the formula given in the last section may be adopted. The extra solvents should not be added (see page 275). After it has ripened for from sixteen to twenty-four hours, the next step is—

Evaporating the Solvents.—An emulsion generally may be prepared in the afternoon of one day, well shaken before leaving the laboratory, and on the next day, about noon, the emulsion will be ready for drying. The mode adopted by the writer is as follows. The emulsion is poured out into a flat dish to a

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* Some few nitrates are soluble in alcohol.

depth of a quarter of an inch, and placed in a dark room, the temperature of the latter being raised, if possible, to 70° (21 *C*.). For every ten ounces of emulsion made, a porcelain dish about 14 by 12, by three-quarters of an inch deep, is required.

After a short interval, it will be found that a skin forms on the surface of the collodion; this is broken through with a glass rod, and a fresh liquid surface given to it. Every half-hour the whole of the emulsion is thoroughly well stirred up, till it begins to break into lumps, when it can be left a short time for the solvents still further to evaporate. It is ready for the first washing when the lumps require a little force to break them up—in other words, when they are about the same consistency as a collodion film before dipping into the bath. The mass is then removed to a glass beaker, and covered with distilled water. At this point we have a good test as to whether the evaporation of the solvents has been continued far enough. If evaporation has not been continued far enough, there is a tendency for the cotton to be little changed in quality. If only a few of the lumps rise to the surface, the evaporation has been sufficient; if, on the other hand, the majority float on the surface of the water, it has not been continued long enough. The reason of this tendency of the lumps to rise to the surface is due to the light specific gravity of the ether and alcohol, which, even with the weight of the solid matter, is not sufficient to counterbalance the specific gravity of the water.

The foregoing is the simplest, but rather wasteful, method, and resort may be had to a still * by which to evaporate and collect the solvents; but in this case the nitric acid must be omitted if the solvents are to be used again, and the elimination of fog-producing products takes place in the first wash water.

For every 100 parts of emulsion, 1 part of nitric acid, which will be ample to secure freedom from fog, should be added to the wash water. After a couple of hours the true washing may commence.

Another plan is to wash in a couple of changes of water, and then to add hydrochloric acid (1 part of hydrochloric acid to 20 of water) to the next wash water, and again wash. This is an effectual plan of eliminating fog, and the pyroxyline is not altered in quality by this acid.

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* See *Photography with Emulsions*, p. 225.

The emulsion may be placed in a jar or jam-pot, and be covered with water, where it can stand two or three hours in the dark without detriment, when it should be changed. The way in which the washing can be economically effected, as regards time, is as follows :—A piece of coarse calico which has previously been washed in carbonate of soda, and then well rinsed and dried, is spread over the top of a second glass jar or large jam-pot, and the contents of the first thrown on to it. The calico acts as a strainer, and the solid pellicle is left on it. The calico is next taken up by the sides, and the contents are twisted up in it, and as much as possible of the liquid then wrung out. The calico is untwisted, and a bag formed (by tying up the ends) to hold the emulsion, which is shaken up and immersed in fresh distilled water. After a quarter of an hour the wringing operations are again proceeded with, and this process repeated three or four times. The expelled water should now be tested for free silver nitrate by a drop of hydrochloric acid. If it gives more than a slight milkiness, such as is produced by adding silver nitrate to water containing a grain of common salt to the gallon, it must be washed till this maximum is attained.

Preparing the Pellicle for Re-emulsifying.—A very important part of emulsion-making is now to be touched upon, viz. getting rid of the water held in the pellicular mass.

To commence with, as much water as possible should be squeezed out, and then we may proceed in one of these ways.

1st. We may lay it out flat on a piece of blotting-paper, and allow it to dry spontaneously. 2nd. We may put it in a flat porcelain dish, and place it in a water bath, the temperature of which can never exceed 212° (100° *C.*), and thus all moisture may be got rid of. In this last proceeding the very greatest care is necessary, as the emulsion is apt to become very hard indeed, so much so as to be scarcely soluble, in addition to which it is often apt to blacken spontaneously. 3rd. This method is one which we can confidently recommend for washed emulsion, being very simple, and absolutely improving its qualities when re-dissolved. This is simply to cover it with rectified spirit (·820) after as much water as possible has been squeezed out. In an hour's time the excess is drained off, and the pellicle is squeezed in the cotton rag as before. It is then once more covered with the spirit, and left for half-an-hour, when, after drawing away the superfluous spirit, it is ready for re-emulsifying. If it be desired to keep the pellicle in a solid state, it will only be necessary to expose it to the air for a few hours, when it will be found quite dry.

It is instructive to examine the washings from the spirit. It will be found that there is a certain small quantity of silver bromide in suspension, which can be filtered out. If the spirit be distilled over, a semi-opaque liquid residue will be left, having a very high boiling-point, a strong and disagreeable smell, and containing some organic salt of silver, which discolours in the light. It may be said that this organic compound is necessary for density of image, but a trial of the emulsion washed in this way will prove the contrary; in addition to which it will be found much freer from spots than that washed and dried by the first two methods indicated above.

There are some pyroxylines which it would be dangerous to treat in this manner, since they are soluble, to a certain extent, in absolute alcohol; but it seems to the writer that any such pyroxylines are detrimental when washed collodio-bromide emulsion is in question. If they are employed, the first or second method must be adopted.

The dried (or moist with alcohol) pellicle has next to be dissolved in its proper proportions of solvents, which is about 12 per cent. of pyroxyline. It is better to make it up first to the strength of 9 per cent. of pyroxyline, and then to add the remaining solvents, since the colour of the emulsion seems to be better when a greater degree of viscidity is present when the pellicle begins dissolving. In two or three hours the whole of the silver bromide should be in suspension. It will be found, however, that there is an improvement in the quality of the film after a lapse of a couple of days, or even more. A plate should be tried before diluting down the collodion with more ether and alcohol, in order to test its flowing qualities, and to notice the opacity of the film.

In our own experience, we like a plate through which, when freshly coated, the light from a gas-jet can just be distinguished, but which, when dried, is very nearly opaque. In this condition the film is tough, seldom requires backing, and is always capable of giving sufficient density by alkaline development alone.

The plate can now be simply coated with the emulsion, and when dried is ready for use. As the result of hundreds of experiments, the writer has unwillingly come to the conclusion that a washed emulsion without a preservative of some kind is a dangerous process in which to place absolute trust. Films which would give perfect negatives, free from those spots which refuse to develop, may, after keeping some time, show them in perfection, spoiling every picture taken upon them.

The reader may employ almost any kind of preservative—an ordinary dark solution of tea or coffee, a one per cent. solution of tannin, a five per cent. solution of gum guiacum, beer, stout, or a five per cent. solution of albumen, for instance. The following is one recommenned by the late Colonel Stuart Wortley :—

No. 1.

Salycine, enough to make a saturated solution in distilled water.

No. 2.

Tannin	60 grains	60 *parts*
Distilled water	1 ounce	440 „

No. 3.

Gallic acid	48 grains	48 *parts*
Alcohol	1 ounce	440 „

To make the preservative, take of—

No. 1	2 ounces	2 *parts*
No. 2	1 ounce	1 *part*
No, 3	$\frac{1}{2}$ „	$\frac{1}{2}$ „
Sugar	40 grains	$\frac{1}{10}$ „
Water	7 ounces	7 *parts*

This preservative may be used over and over again with occasional filtering. The plates are best immersed in it.

A substratum will in many cases be required, though often, by first washing off the preservative, then allowing the film to dry, and flooding with alcohol, and again washing, and then proceeding to development by the alkaline or ferrous oxalate developers (pages 277 and 179), any tendency to blister, or unequal development of the image, will be prevented. Those who have not the time to adopt this method must use the substratum, if a gum or albumen preservative be used, an edging being of but little use, and unless the preservative be soluble in alcohol. The method of applying alkaline development has already been given at page 278. The mode of developing with ferrous oxalate is as follows. If the saturated solution of the developer (made by dissolving ferrous oxalate in a saturated solution of potassium oxalate) be used, we dilute it with half its bulk of water, and add to every ounce (1 *part*), 1 drachm ($\frac{1}{8}$ part) of a four per cent. solution of potassium bromide in water, and apply this to the film after washing, as described above. If the image appears slowly, we add half the original quantity of the ferrous oxalate undiluted, and then, if the exposure be anywhere near correct, this will bring up the requisite density. Should more density be required, we intensify as given at page 179.

Should the image refuse to come out even with the stronger developer, one drop of a ten per cent. solution of sodium hyposulphite to each ounce of developer will have an accelerating effect (see page 180).

The exposure required for this development seems to be about two-thirds of that required for the alkaline developer given above, and is, therefore, a decided gain to the photographer.

There is a great charm in this developer, the plates gaining intensity steadily, and without any tendency of being overdone; and the negatives give brilliant prints.

A modification of the ferrous oxalate developer, which the writer calls citro-ferrous oxalate (see page 192), is also applicable for development. It works rather slower, but can be used without the addition of any bromide. The solution is mixed with an equal bulk of water, and the development modified and carried on as above described for the ferrous oxalate. The sodium hyposulphite may be used with it as with the ferrous oxalate developer.

It may be asked what advantage a washed emulsion has over an unwashed one, since with both a preservative is recommended? It is this. If an unwashed emulsion in which there is any large excess of silver present be kept longer than just to ripen it, it becomes transparent, and loses all its "creaminess," and then loses its sensitiveness in a great measure. When an emulsion is washed, it remains in the same state of sensitiveness from year's end to year's end, supposing a suitable and properly-washed cotton to have been used.

Besides the defects noticed, there are a few others which must be alluded to.

Crape markings in the film are usually due to the solvents of the emulsion being too aqueous; or they may be due to the emulsion not having been shaken up shortly before being used; or to the bromide being too coarse.

Thin, transparent films with washed emulsion are usually due to the last two causes.

The emulsion refusing to flow properly is due to deficiency of solvents. This is frequently met with if the same emulsion be used for many plates. It should be diluted down with one part of alcohol (·812) to two of ether (·720).

When the film tends to peel off the plate, the pyroxyline is probably of too contractile and horny a nature, in which case the proper treatment is to mix it with an emulsion made with one of a more powdery character, or to mix 1-20th part of a saturated solution of gum-guiacum in alcohol with it.

The cause of fog has been pointed out in Chapter III. To eliminate it in a washed emulsion, the careful addition of a few drops of a dilute solution of iodine in alcohol will prove effective. With such an emulsion, when used with a preservative, a dip in a ten per cent. solution of hydrochloric acid in water will eliminate all fog. In an unwashed emulsion the addition of nitric acid will effect a cure.

CHAPTER XXIX

PAPER PROCESSES

It might seem too retrograde to describe one of the old paper processes, but it remains yet to be seen whether they may not again come to the fore for prints, or even for negatives under certain circumstances, so we give two processes, both of which yield excellent results, and the last is very fairly rapid. The first is known as Greenlaw's process.

First examine and select thin negative paper, and reject all that shows any irregularities, holes, patches of unequal density, etc. That recommended for Buckle's process will answer. Make a solution of—

Potassium iodide ...	1000 grains ...	100 *parts*
Potassium bromide ...	300 ,, ...	30 ,,

For much foliage the latter may be increased to 450 grains (45 *parts*).

Distilled water ...	40 ounces ...	1760 *parts*

and add enough iodine to give the solution a dark claret colour. Then filter.

Into this place as many sheets of paper as you can with ease, being careful that no air-bubbles exist. Allow the paper so immersed to rest for an hour; then turn the whole upside down, and hang the sheets up to dry, taking off the last drops with white blotting-paper. This may be done in diffused light. When dry, place sheet over sheet evenly in a portfolio in which no other papers, except blotting-paper, are placed. They will then be iodised a dark purple, which will keep any time. They, however, turn a light brown colour. Be sure, in working, that nothing touches the paper, for the very slightest touch will cause a stain in the development. Prepare—

Silver nitrate ...	... 2½ ounces ...	2½ *parts*
Glacial acetic acid	... 2½ „ ...	2½ „
Distilled water ...	... 40 „ ...	40 „

Now float a sheet of your iodised paper on this (smooth side downwards) until the purple shall have turned an uniform yellow, which is silver iodide. Allow it to rest for one minute; after this, remove and immerse in distilled water, where it should remain for two or three minutes; if to be kept for some time, remove to another dish of distilled water. Place now on clean white blotting-paper, face upward, and remove by blotting-paper *all* moisture from the surface (these sheets can be again used for ironing out the wax by and by); then place between blotting-paper, and hang up to dry; when quite dry, place in your dark slides. Next prepare—

Gallic acid ...	... 200 grains ...	200 *parts*
Spirit of camphor	... 1 drachm ...	55 „
Distilled water ...	... 40 ounces	17,600 „

This is a saturated solution of gallic acid; unless preserved from the air, it decomposes; the spirit of camphor is added to preserve it. When about to develop, filter, and add to every five ounces one drachm of the following solution:—

Silver nitrate ...	... 30 grains ...	30 *parts*
Glacial acetic acid	... ¾ drachm ...	38 „
Distilled water ...	... 1 ounce ...	440 „

Pour into your dish quickly, and *immediately* float the picture side of your paper (which is slightly visible on it), being very careful that there be sufficient liquid to prevent the paper from touching the bottom of the dish. Constantly watch until the picture becomes visible on the back, and the paper has a kind of brown, greasy appearance. Continue the development until, in holding up a corner when the sky is before the light, you cannot see your finger when moved about between the light and the paper. If it be not dark enough before the silver gallate decomposes, you have under-exposed. Decomposed gallate of silver ceases to develop.

Do not, when examining your paper, lift more than the corner, as an oxide of gallate of silver forms rapidly on the surface like a crust, and, on replacing your picture, it causes innumerable marble appearances; as also if you do not place your paper speedily on the solution in the first instance. It may be removed by drawing a sheet of blotting-paper over the surface of the solution. Remove to a dish of common water, and wash out the brown tinge caused by more or less decomposed gallate of silver.

We have found that this paper can also be easily developed by a brush. For our own part, we prefer to brush the developing solution over the paper, wetting the paper first, however, with water. We use a three-inch flat badger-hair brush. The image can then be worked upon by increasing the strength of development at different parts to bring out detail or intensity. The foregoing sketch (Fig. 141) will show the plan we adopt.

Fig. 141.

A A is a wooden stand, and C a glass plate, on which the damped paper is placed, standing in a zinc trough, B. The stand is placed on a table a convenient height at which to apply a brush. All solutions are caught by the trough, B, and perfect cleanliness is thus maintained. A wooden board may be substituted for the glass plate, taking care, however, to place a piece of clean and damped paper on to it on which to place the paper negative. In this case, a couple of drawing-pins may be used to hold the top corners of both sheets. The three-inch badger-hair brush is now brought into requisition, and the image "brushed" out. This method necessitates but a slight amount of developer to be employed, and hence is economical. It is then finished with the above solution of gallic acid, and then with the gallic acid and silver. The image appears rapidly, and there is never any danger of a stain from decomposed gallate, as constant fresh solution is applied. Two ounces of solution is found to be capable of developing a 15 by 12 picture, which is far less than would be used by developing as Colonel Greenlaw recommended.

When *well* washed, you may fix the negative by placing it in a solution of sodium hyposulphite, 1½ ounces to 1 pint of water, till every vestige of the yellow silver iodide be removed, after which it is washed in eight or ten different changes of water; you have then a fine, clear, and dense negative. The colour of the image produced by this development is hardly suitable for prints, being greenish.

Process for Alkaline or Organic Iron Development.—Colonel Greenlaw's process may be modified to suit alkaline or organic development. The paper is prepared in the manner given, but it is advisable to reverse the proportions of bromide and iodide. The formula will thus stand:—

Potassium iodide	300 grains ...	30 *parts*
Potassium bromide ...	1000 " ...	100 "
Water	40 ounces ...	1760 "

and the iodine is added for the convenience of ascertaining when the sensitising is complete.

The paper is floated on the silver solution as usual, but there is no need to introduce the acetic acid; in fact, an ordinary bath prepared for printing will answer well if it be not discoloured. After floating, the paper may be thoroughly washed, and then exposed; or it may be placed in a bath of common salt solution:—

Common salt	400 grains ...	40 *parts*
Water	40 ounces ...	1760 "

The paper is allowed to soak in this for ten minutes, when it is washed. A moderate amount of washing suffices, since the presence of a minute quantity of salt is not detrimental to the sensitiveness. The salt prevents the formation of any organic compound of silver. When dry, it is ready for exposure, which should be as long as that required for a bath dry plate, or about three times that required for a wet plate. To develop, the paper may be immersed in a solution of—

Strong ferrous oxalate	1 *part*
Potassium bromide solution (20 grains 1 ounce, *i. e.* a 4 per cent. solution)...	½ „
Water	1 „

Instead of this, it may be immersed in a solution of ferrous-citro-oxalate (page 192). The development takes place with moderate rapidity, and should be carried on till the image appears perfectly dense by transmitted light. The plan of brushing on the developer may also be employed as above.

Should additional intensity be required, it can be given by soaking the print in acetic acid and water, and then applying the ferrous sulphate solution (page 228). The best alkaline developer for this paper is that in which washing soda or potash is used in conjunction with sulphite of soda (see pages 162 and 163). The development with it is very easy, and the paper is unstained by it. If iron be used as a developer or intensifier, immediately after its use, and before fixing, the negative should be immersed in a solution of acetic acid and water (1 part to 20), to prevent insoluble oxides of iron forming in the paper. When washed, the paper is fixed as in the preceding process.

Bromide Paper.—A very excellent paper can be prepared with silver bromide alone. To prepare it, the paper is immersed or floated on a solution of—

Potassium bromide ...	800 grains ...	80 *parts*
Water	40 ounces ...	1760 „

It is then floated on a solution of—

Silver nitrate	30 grains ...	30 *parts*
Nitric acid	2 minims ...	2 „
Water	1 ounce ...	440 „

It is then washed, and soaked in a weak (1 per cent.) solution of potassium bromide, to which about ½ per cent. of nitric acid is added. It is again washed and dried. This last bath is not always necessary. It is only so when, on trial, the paper after washing is found not to be quite brilliant in the whites.

To develop, the paper is treated with any of the above developers. It should be noted that the exposure with the bromide paper is considerably less than with the bromo-iodide paper. It may be developed in a dish or by the brush, but care is required to keep the whites quite clear. We may say that, as a rule, the alkaline developer, to which sulphite of soda has been added, gives the purest whites, as it does with the gelatino-bromide paper. When the paper is developed and fixed as above, and washed, it is dried, and is then ready for washing.

The colour of the image by this process, when development is by ferrous oxalate, is usually of a beautiful brown tone, and would yield excellent prints.

If any of these images are negatives, they should be waxed, as given at page 200.

CHAPTER XXX

HAND-CAMERA AND FILM PHOTOGRAPHY

In the market at the present time, there are a great variety of what are called hand-cameras—that is, cameras which are held in the hand during exposure. It is thought that, as these have become so generally in use, a few remarks on the method of using them may not be amiss, more particularly as there are many amateurs whom we have met who have made what ought to be called failures through not knowing some simple rules to follow. The remarks that will be made apply not only to hand-cameras in which glass plates have to be used, but also to those in which films are the sensitive receiving surfaces.

A hand-camera should be of such dimensions and weight that it can be carried without fatigue. An arm that carries a heavy camera will soon become incapable of holding it approximately steady, and as steadiness is an essential for sharp pictures, this practically bars to the general public a size, at all events, larger than a half-plate. For ladies, and photographers who are not of the most stalwart order, a quarter-plate size is perhaps the best. It has the advantage that sharper pictures can be taken with it than with a larger size, for with equal angular apertures "the disc of confusion" of the $\frac{1}{100}$ inch, by which a point of light is represented when the focus seems sharp, is obviously arrived at with a larger angular aperture of diaphragm with a lens of short focus than with one of long focus. Every hand-camera should possess a level, an accessory much more necessary than a view-finder, since by it alone can architectural subjects be properly placed on the plate. A view-finder is useful, but lines drawn on the top of the camera to show the angle included is often sufficient for the expert.

Roughly speaking, cameras may be divided into three classes—those which take plates only, those which take thin films only, and those which take both. The first class may be divided into two divisions, those which take slides, and those in which there is a magazine of plates. Of the former, that which is best known to the writer is the Key camera, which is made to take $\frac{1}{4}$ plates, and also a larger size to take 5 × 4. It should be furnished with two view-finders and two levels, so as to take "horizontal" and "vertical" pictures. A moving front is also a desideratum with it; and the makers have made it on a very ingenious plan. The experience of the writer is, that it is safer to cover the orifice into which the circular end of the slide fits with a small piece of thick cloth. A slit is cut in this through which the slide passes, and effectually seals the opening when the plate is being inserted or withdrawn.

Fig. 142.

The shutter is one which works between the lenses, and can be "slowed" down by means of a small break. The greatest rapidity of the shutter appears to be about $\frac{1}{80}$ second. This camera will also take celluloid films, carriers for which the makers supply.

As to magazine cameras, a few words are necessary. Some seem to work excellently, and others are really poor contrivances, which for a time seem to have a perfect movement for changing plates, but which afterwards get out of order. The writer prefers a camera which has separate slides or plate-carriers, though this is merely a matter of opinion. It must be recollected that if one plate in a magazine camera is spoilt, all are spoilt, and that any particular plate has to be picked out for development from a large bundle.

Cameras to carry rollable films only are practically the monopoly of the Kodak Company, who have various types, all excellent in design, some thoroughly useful, and others which are intended to be memorandum cameras only, as for instance the folding pocket kodak (Fig. 145). The shutter for these last is an excellent one of its kind, and can be regulated to a certain extent (Fig. 143). In the larger class of kodaks, as for instance in No. 4 cartridge kodak, there is a means for raising the front for vertical as well as for horizontal pictures (Fig. 144). It has a lens which works with a wide aperture, and a type of shutter which can be regulated. It should have bright view-finders, and also lenses attached.

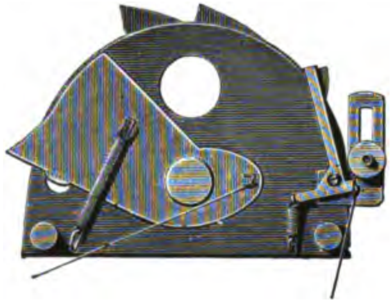

Fig. 143.

These kodaks carry twelve exposures self-contained, and new rolls of twelve exposures can be inserted in daylight, which is a great advantage. The films, however, have all to be exposed before development can take place, except by a loss of a piece of film which is equal to one exposure. The convenience, however, more than counterbalances this disadvantage. The films supplied are bright, and give good

Fig. 144.

dense images, more particularly when the pyrogallic developer is employed.

Fig. 145.

Fig. 146.

There are other kodaks which take plates or films, and which are box-cameras (Fig. 146).

The ideal camera is one which will take either plates or films. If the camera is constructed so as to take double backs with plates, the films can be utilised if the camera be supplied with one of those extremely useful "cartridge-roll holders" which the Kodak Company supply.

Fig. 147.—Cartridge-roll holder.

Fig. 148.

Marion's "Swallow" hand-camera is in the form of a leather covered box, size 8¼″ × 7″ × 4″. It is fitted with a doublet lens provided with an Iris diaphragm full aperture F/8, and can be focussed for objects at any distance by means of convenient mechanism and a focussing scale. The shutter is released by hand or pneumatic pressure, and can be set for time or instantaneous exposures, four different speeds being provided. There are two finders and two spirit-levels. The plates (twelve in number) are carried in sheaths; films may be used if they are backed up with cards. The mechanism for changing the plates is convenient to use, and is not likely to jam in action. The camera is fitted with screw-bushes by which it can be attached to a tripod. A cheaper form of the camera is made to carry thirty cut films.

Marion's "Radial" hand-camera is made in five sizes from 3¼ × 3¼ to half plate. The camera is arranged to carry twelve plates, which by means of the changing apparatus may be exposed in the same rotation in which they were placed in the magazine, or in any other order. Special carriers have been recently introduced by which twenty-four films may be carried in place of the twelve glass plates. The camera is fitted with a doublet lens working at F/8 with rotating diaphragms, has a focussing scale, time and instantaneous shutter, and two finders. The plate-changing apparatus will be understood by reference to the illustration, and being carefully made in metal is likely to prove reliable. As full instructions are given with the camera, it is sufficient to say that the plates are placed in the radiating grooves seen at the rear end of the camera, and when one is required for exposure it is slid into the rotating carrier seen in the centre of the camera. This

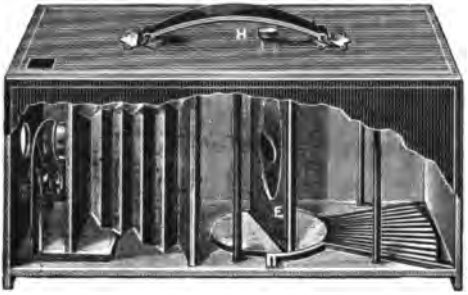

Fig. 149.—Side view showing interior.

carrier is then turned to face the lens, and after exposure the plate is returned to its groove in the magazine.

To bring a Plate into
Exposing Position and to
return it to its Groove.

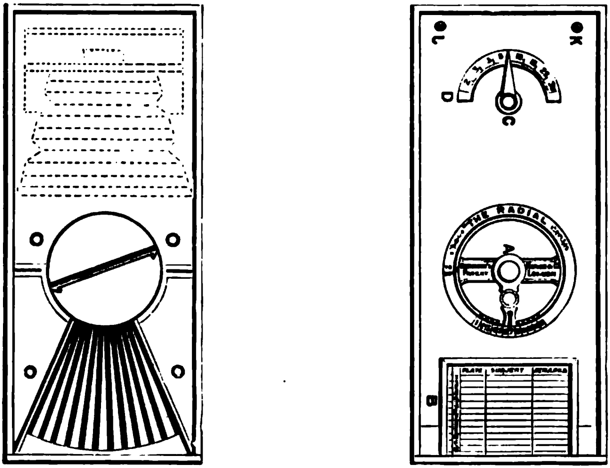

Fig. 150. —Base fittings.

Watson's "Alpha" hand-camera is a convenient instrument

for those who prefer to carry their plates in dark slides rather than in a magazine. The camera has an extension sufficient to accommodate the lens when one combination of the doublet supplied with it is used as a single lens. It has a swing-back, rackwork focussing adjustment, exposure shutter for time or instantaneous work, a finder, three double dark slides, and a leather travelling-case with lock and key.

Fig. 151.—Showing camera open and closed.

Exposures.—Most hand-cameras have the exposing apparatus set in motion by pressing a key. Those who practise rifle-shooting will know that if the trigger is simply *pulled* by the finger the muzzle of the rifle will sink, whereas, if *pressure* be applied by the finger acting against the thumb, there will be no drooping of the barrel. The same mode of procedure should be adopted in setting the shutter in motion; the catch should be liberated *by a pressure, and not by a pull.*

As to holding the camera, there are many different plans adopted by photographers. Some press it against what we may call their "lower chest," using both hands to steady it. This position we hold to be a mistake, as drawing the breath, etc., may give it a shake during exposure. The plan the writer adopts is to hold it against the true chest, which is fairly rigid, and where the view-finder and level can be well looked at. Some hold it against their hip, but as a rule this is too low, since it is so far below the usual height of the eye. Others, again, hold it below the chin, which is not a bad position.

As to the light in which a hand-camera can be used, there is not much to say. It is not always the brightest day which gives the best pictures. On a bright day, in which the sky may be, perhaps, cloudless, shadows are invariably heavy, and it is frequently difficult to get detail in these dark portions. A fairly bright day, with white, fleecy clouds about, is that which gives the best results. Even on a cloudy day with no sun shining it is possible to obtain excellent results. In the early morning in summer, or the late afternoon, the photographic power of direct sunlight is far below that which it possesses towards noon; but the skylight does not deteriorate in the same degree, and excellent pictures may often be obtained on an October day about an hour before sunset if the weather be clear. The advice that is given is to use an actinometer of some kind (Watkins' is excellent for the purpose), and judge exposures according to it, holding it, in the case of a sunny day, at right-angles to the direction of the sun.

Nearly every lens is equally transparent to photographic light, and a choice should be made of one to use in which spherical aberration has been largely eliminated, so that general sharpness of image may result.

The plates used should be as rapid as can be obtained, if, at the same time, they give a fair amount of density.

Lenses.—A word must be said about lenses for hand-cameras. The lens that is most useful is the lens that can be used with the largest aperture. There are several lenses in the market which will give sharp pictures with an aperture of *f*/6·4, or thereabouts, and any one of that type should be used. It must be remembered that a stop of *f*/6·4 means that the light admitted to the plate is sixteen times more intense than if *f*/16 be used. The lenses such as Dallmeyer, or Taylor, Taylor and Hobson, or Ross, issue are types of the lenses referred to, and give sharp images at the corners of the plates, being corrected not only for spherical aberration, but also for astigmatism. Some lenses will not take a shutter between the components, and recourse must be had to some other form of shutter, such as Thornton and Pickard's blind shutter. For our own part we like this form when placed behind the lens, as it enables the photographer to change lenses by means of adapters, without altering the shutter. Lenses with aluminium mounts are lighter than those with brass mounts, and if possible this material should be insisted upon. Again, in a hand-camera the lens should be capable of being raised in a vertical and horizontal direction in order to raise or lower the horizon line in the picture, and so avoid a tilt. If the camera has to be tilted, a swing-back must be supplied, but this introduces an unnecessary complication. Again, a hand-camera should have a shutter which can give not only an instantaneous but also a time exposure, in which the full aperture is exposed when the finger presses the release button and closes when the finger quits the button. With a lens such as indicated, and with a time exposure, pictures on really dark days are obtainable.

View-finders.—A hint may also be given as to view-finders. The view-finder most often supplied is one which gives an image on a ground glass. In bright sunshine or on a dull day, the image thrown is very feeble, and can scarcely be distinguished. The bright view-finder with a virtual image thrown by a lens is much more satisfactory, since in every weather and kind of light, the image thrown on the eye is as bright as the original. It is often stated that these "bright" view-finders are unsatisfactory, because the image moves as the eye shifts. This is not the case with the best forms, though it is when the image is formed by a concave mirror. Our advice is that the camera should have a view-finder of this kind.

Development of Plates exposed in Hand-Cameras.—There is not much to be said regarding the development of plates which have received instantaneous exposure. It may be taken for granted that the plate will not be much over-exposed, but it may be considerably under-exposed, and it is from the latter point of view that development should take place. The reader is referred to page 156 for the plan that should be adopted.

Development of Films.—The development of films is a rather more complex subject, not on account of chemical considerations, but solely because of the mechanical difficulties that arise. We would propose to take the reader through the manipulations during development of a film from a cartridge-holder, which has twelve exposures completed. These films are covered with a long band of black paper, which has been in contact with the film when wound round the bobbin. When the cartridge of exposed film is taken out of the slide, it should be unrolled carefully in a feeble non-actinic light, for these films are sensitive to red light before development takes place. At one part there will be found a line of perforations across the film which marks the end of one half-dozen exposures and the beginning of another half-dozen. The film should be cut across through these perforations, and the remainder rolled up on the spool. Before this, five ounces of developing solution is poured in a deepish dish that will hold a half-plate, and placed over a sink or on a table of convenient height. A large jar containing a gallon or more of water is also placed handy, and when the film has been cut it is gently lowered into the water, care being taken that it is equally wetted all over at the first immersion. It is drawn up and down in the water once or twice and allowed to rest a minute. The film is then held by the two hands in a loop, *gelatine side down*, and one hand is lowered till the end touches the developing solution in the dish, the other hand being raised so that the film does not rub against the dish. The first hand is then gradually raised, the other hand being simultaneously lowered till the whole film has passed through the developer.

The band of film is again drawn through the developer, and the operation repeated until the six images begin to appear. The operator may now choose whether he will continue the development of the six together, or whether he will develop them one or two at a time. If the former, he continues the operation of drawing the film through the developer until the image appears quite dark (nearly black) through the celluloid film. The fingers sometimes are apt to be immersed in the developing solution, and the small quantity on them may run down and cause streaks of increased density. It is a good plan to use glass clips, to be held in the hands. These clips can be made by a couple of pieces of glass (rather narrower than the breadth of the film) separated by a wooden match, and a spring formed by a strong elastic band stretched over the two.

It may be remarked, that as soon as the image begins to appear, more light may be used to illumine the dish, as the film becomes comparatively insensitive. When the development is completed the film may be bodily rinsed in the jar of water, and transferred to a jar of hyposulphite solution, or the separate pictures may be separated by scissors, and then be transferred to a deep dish containing hyposulphite solution. Care must be taken that the films are immersed in the solution, and that they do not adhere to one another, as if they do marks are likely to occur from development continuing.

The other plan of development is to stop the backwards and forwards motion when the images are just appearing, and to place the band in water. The pieces of film are then cut through and placed in the developing dish for development to be completed. When the subjects vary in character, and when the light or exposure may have been different, this is the best plan to adopt. It will be found that although placed in the water the pictures will continue to develop, though more slowly than those in the dish. (A few drops of citric acid in the wash-water will materially check this development if desired, and it does not appear to affect the subsequent development.) Each picture is then separately developed, and after rinsing placed in the hypo bath. It will probably be found necessary to use means to keep the films in the solution, and this should be done with a glass rod, and care should be taken not to bring the hot fingers in contact with the back of the film more than necessary. The development should take place *gelatine side downwards*, and the sufficiency of development must be judged by the dark colour of the image through the back of the film. In fixing, much of the opacity is lost, and a film which appears almost opaque before fixing may prove to be really not sufficiently opaque when fixed. It is better to overdo the opacity than to underdo it. In case of over-exposure, before the film has its final development, it may be rinsed in a solution (5%) of hydrochloric acid, and again washed. This prevents the image from becoming flat, and a vigorous image may be obtained by this procedure. The ortol developer, page 172, is excellent; but perhaps the best developer for giving a vigorous image is that recommended by the Kodak Company, made as follows—

No. 1.—	Sulphite of soda	6 ounces
	Hot water	32 ,,
	When cold, add—	
	Pyrogallic acid	1 ounce
No. 2.—	Carbonate of soda	3 ounces
	Carbonate of potash ...	1 ounce
	Water	32 ounces

To Develop: Take, for normal exposures, one part each of No. 1 and No. 2, together with two parts of water.

Unless the carbonate is very pure, this last developer is apt to turn brown during the development. It gives a greenish image, which is very non-actinic in character. In the process of fixing it is absolutely necessary that the whole of the film be kept under the hyposulphite solution, as if not there will be stains due to discoloration of the pyrogallic acid, and also from the development continuing due to the solution left in the film. When fixed, the negatives should be washed in frequent changes of water, or for twenty minutes in running water. They should be finally soaked for four or five minutes in a solution (5%) of glycerine in water to prevent the films curling when dry. The drying is best done on a board. Each corner should be fixed with a pin, the gelatine film being outwards. Drying may take some considerable time in damp weather, owing to the absorption of moisture by the glycerine. The negatives should be piled in books or envelopes, with clean blotting-paper between each.

Intensification.—Perhaps the best method of intensification is by the mercury process, followed by ferrous oxalate. (See page 186.)

CHAPTER XXXI

COPYING PLANS, ENGRAVINGS, ETC.

IN reproducing plans, engravings, etc., by photography, a single lens should not be used, owing to the curvature of the image given to the marginal straight lines. This confines the choice to the landscape doublet and triplet, and to portrait combinations. Of these the doublets are the most satisfactory. With lenses obtained from first-class makers there is no distortion; the reflecting surfaces are fewer in number than in the triplet combination, and therefore are to be preferred. The triplet seems to have a flatter field; in bright weather, therefore, when there is plenty of actinic light, it may be used with advantage. Portrait combinations also answer; the general objection to them, however, is that the field is so concave as to be out of focus at the margins, unless one of large diameter be used.

If the plan has to be reduced by photography with the aid of a portrait combination, it is preferable to have the front lens next the plan to be copied; if it has to be enlarged, the combination should be inverted, and the back lens placed in front.

A direct light, coming in a horizontal direction, is generally to be preferred for copying, as the texture of the paper is hidden by it. If a vertical light be used, the shadows of the irregularities on the surface of the paper may mar the purity of the whites.* Should the plan or drawing be shaded in flat tint, it may be necessary to copy it in direct sunlight, as

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* In copying certain classes of drawings, the writer has found that light admitted through a funnel-shaped box, formed of tissue-paper stretched on laths, prevents the irregularities of the paper showing. In copying prints from albumenised paper, etc., the same procedure may be followed.

Indian ink and sepia, and some other colours, are of such a non-actinic nature as to make but slight impression on the sensitive film; strong light lightens up the shades, which are only dark by comparison.* For like reasons, plans or engravings on paper which, through age or other causes, has turned yellow, should be copied, if possible, in sunlight.

If the reader be lucky enough to have an electric light, he will be enabled to copy plans even at night with the greatest ease. The following arrangement has worked well with the writer. A common lens, some three to four inches in diameter, is placed near the light in such a manner that it throws a disc of light just larger than the plan to be copied on to it. The light is very intense, and half-a-minute's exposure should suffice with it. Failing the electric light, if a foot, or two feet, of magnesium ribbon be burned behind the lens, so as to give the same disc of light, a good negative may be taken. It may be useful here to state the photographic values of some artificial lights in terms of the photographic value of a standard candle, the photographic value being taken as the effect on bromide of silver:—

Light of the optical value of a standard candle.	Photographic value in terms of standard candle.	
Standard candle	1	
Ordinary paraffin candle ...	1·3	
Oxyhydrogen light, blow-through jet	2	
Electric arc light	10	
One grain of magnesium ...	15	burning 1 minute.
Bright sun at noon in summer ...	21·6	

It will be noticed how the optical and photographic values differ. It might be thought that, although these differences do exist, yet, by increasing the smaller number, the same effect might be obtained. It must be recollected, however, that the electric light radiates from 1 to 10,000 candles from a very small area, and that, to make the same photographic illumination, the number of candles would have to be the same, but multiplied by 21·6 Thus, if an electric light

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* In certain cases, orthochromatic plates may aid in rendering the flat washes.

radiated 1000 candles, the number of standard candles that would have to be employed would be 21,600, a number which would never be concentrated in any reasonable area. Sunlight may be taken as equal, optically, to 5600 candles placed at 1 foot from the object illuminated.

The Welsbach incandescent gas-mantle omits a good photographic light (see page 332), and acetylene gas is powerful on account of its brilliancy. If two of either of these illuminants are placed one on each side of the plan to be copied, and shielded so that the light from them does not fall direct upon the lens, good results will follow.

Slow gelatine plates are usually the best for copying purposes, as they give denser images. If home-made, they are best made by the ammonia process (the formulæ given in Chapter XI.). If boiled emulsion be used, the boiling should only be for five minutes. Of course the plates are slower, but they take great density with ferrous oxalate development. It is no use using a plate which gives only feeble images; it is merely waste of time, since no mercury intensification will make it fit to give perfectly black and white prints, which is a desideratum for this speciality.

For copying, however, the writer always prefers to use the wet process, since clear lines and a dense background can readily be obtained. A bromo-iodised collodion yielding intense negatives answers well for ordinary work. The addition of a grain or two of pyroxyline (or, better still, papyroxyline) which has been washed in dilute ammonia will often cause a limpid collodion to become fit for copying purposes. The alkaline reaction in collodion gives intensity, and this is further increased by the addition of the pyroxyline.

The bath should be free from any impurity, and may be of the ordinary strength.

For plans or line drawings, the following developer is recommended. The iron may be used even weaker than in No. 1, and may be as follows:—

Ferrous sulphate	5 grains ...	5 *parts*
Glacial acetic acid... ...	10 minims ...	10 ,,
Alcohol	*quant. suff.*	
Water	1 ounce ...	440 ,,

With a simple iodised collodion, pyrogallic acid may be resorted to as a developer. Should this be decided upon, half the acetic acid given (formula, page 226) should be added, otherwise the deposit may become too crystalline in character. In winter, when the light is weak, the iron developer should invariably be employed.

Negatives of plans drawn in lines should never be fully developed, and they should be slightly under-exposed. When the reduction on the whites has taken place, the developer should be washed off, and the negative fixed. By this method all deposit on the lines is avoided.

The negatives will require intensification. In rare instances the simple application of the iodine solution (page 229), followed by the pyrogallic intensifier, will suffice. Should this, however, not give sufficient density, either Nos. 6, 7, 8, or 9 (pages 229 to 231) may be tried in addition.

It requires considerable practice in manipulation to prevent (1st) a stain forming on the lines from the pyrogallic acid intensification, or (2nd) the lines from becoming filled up by a deposit from the intensifier after fixing.

The ordinary procedure of wet-plate intensification should be carried out in copying paintings.

It is safer, after using a solution of mercury on a collodion film, to let the negative dry spontaneously. Rapid drying is apt to cause the film to split.

Collodion emulsion plates may also he used for copying plans, using a preservative such as Colonel Wortley's (see page 282). The intensification may take place by any of the methods given above.

Plates coated with lantern slide emulsion can be obtained in most sizes, and yield good clear black and white negatives.

Special plates made for this class of work, and sold as process plates, can be obtained, and with these excellent work may be done.

Copying Oil Paintings.—The light for copying oil pictures should come from the direction in which the light has been supposed to come in the picture itself. A painter "loads" his canvas in such a manner as to give the best effect to his picture when viewed in that particular light. The subject of the wet process for copying paintings is one somewhat difficult to handle. The colours which are brightest in a painting are the yellows, and, as a rule, these have very little action on an ordinary photographic plate. The blues, which are much less luminous than the yellows, come out light instead of dark. There are two methods of attack: one would be by using a plate which is equally as sensitive to the yellow rays as to the blue, and the other is to moderate the blue by some kind of artifice. This has been treated of in Chapter XXXIV.

CHAPTER XXXII

PRODUCTION OF TRANSPARENCIES AND ENLARGEMENTS

The production of lantern slides is a very favourite pastime in photography, and the production of positive transparencies on glass from a negative is necessary, as a rule, for the multiplication of negatives, reversed or otherwise. The following are modes of production by the camera or by contact printing.

Camera Transparencies.—When it is determined to use the camera, if a proper copying camera be not at hand, the following substitute may be employed. B (fig. 152) is any ordinary rough box, the top of which is removed. Out of one end is cut a rectangular portion, C, just large enough to hold the negative from which the transparency is to be obtained. Small pieces of wire are placed across the angles to support the face of the negative. When the latter is placed in position, a couple of pins inserted at the top and bottom of the outside of the opening will prevent it from slipping. Placed as shown in the figure, the light from the sky being reflected through it by a mirror, or by a perfectly smooth sheet of white paper, a transparency may be obtained merely by treating the negative

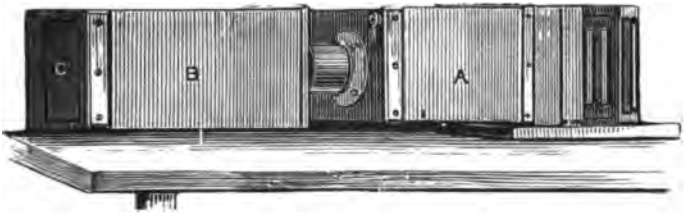

Fig. 152.

as if it were a plan, etc., to be photographed. It has usually been considered that the box holding the negative and the camera ought to be connected together, no diffused light having access to the front of the negative. In practice this is found unnecessary, and where the negative is dense the diffused light is absolutely an improvement. Should it be found advantageous to exclude all light, a couple of battens placed across the negative, and a cloth thrown over them, will answer the purpose. An opening through the outside wall of the dark room may be used to hold the negative. A mirror placed at about 45 degrees with the horizon, and covered over with plate glass as a protection from dust and rain, reflects the clear light of the sky through the negative.

It need scarcely be said that the focussing should be very carefully attended to; a common pocket magnifier is useful where extreme definition is to be obtained on the ground glass.

The negative for a brilliant transparency should be slightly less dense than one suitable for good printing. It is, however, by no means to be inferred that a negative of even great density cannot be copied, but only to be understood that the less dense one will give the finest results with the least trouble.

It may be a matter of opinion, but it is distinctly that of the writer, that wet plates give the finest transparencies. If used, highly bromised collodion is recommended. For ordinary printing negatives the addition of one grain of bromide to the ounce will suffice; for a negative of the weak type the bromide may be omitted; whilst for a dense negative the bromide may be added up to three grains per ounce if the collodion will bear it. The bromide should be added from five to six hours before the collodion is required.

The exposure should be long enough to cause the minutest detail in the negative to be apparent in the transparency. On drying, the points of bare glass should be very few; if not, it may be taken for granted that the exposure is too short. No fixed rules can be laid down for the length of exposure; the operator must use his judgment.

The development for wet plates is carried on with a very weak developer, the strength varying with the density of the negative to be reproduced; the denser the negative, the stronger the developer should be. For a negative of medium density the following may be used:—

Ferrous sulphate	5 grains ...	5 *parts*
Glacial acetic acid ...	5 minims ...	5 „
Alcohol	*quant. suff.*	
Water	1 ounce ...	440 „

For a very dense negative the ordinary 30-grain iron developer (page 227) may be used. Should there be too much contrast, add more bromide to the collodion, and use a stronger developer; if too little, diminish the quantity of bromide, and use the weak developer. Intensification may be carried on to such a point that, on looking through the glass, the *deepest* shadow appears nearly opaque.

The transparencies are better fixed with sodium hyposulphite, as the delicate details might be eaten away in some slight degree by cyanide.

The colour given by silver is not always an agreeable one, and it is generally necessary to tone the image. This may be effected by a platinum salt, a gold salt, or iridium salt, or by a mixture of any or all of them. The formulæ are as follows:

No. 1.—	Ten-grain (2 per cent.) solution of platinum-tetra-chloride in water	1 drachm ...	1 *part*
	Nitric acid	12 drops ...	⅕ „
	Water	10 ounces ...	80 *parts*
No. 2.—	Gold trichloride ...	1 grain ...	1 *part*
	Hydrochloric acid ...	6 drops ...	6 *parts*
	Water	10 ounces ...	4400 „
No. 3.—	Iridium chloride ...	1 grain ...	1 *part*
	Hydrochloric acid ...	12 drops ...	12 *parts*
	Water	10 ounces ...	4400 „

If a mixture in equal quantities by measure of Nos. 1 and 2 be taken and flowed over the plate, a pleasing tone will be given. When toning with gold, a pink deposit is apt to form on the transparent portions, which spoils the effect. Sometimes the platinum solution by itself will give rather an inky colour.

For making prints on opal, the wet plate process may also be adopted. The image is developed with a developer containing citric acid as well as acetic acid, and if the exposure be right, the result is a warm brown tone. In some studios the tone is slightly warmed by toning with ammonium sulphide, which gives a pleasing colour, and is permanent.

Gelatino-chloride plates may also be used (see Chapter XIX. for the different tones which can be got by altering the composition of the developer).

Moderately rapid gelatino-bromide plates are, however, most generally used for camera positives. The development may be with the alkaline developer made with the sulphite of soda, and thus a pure, warm, black tone may be obtained. Ferrous oxalate may also be used. Perhaps eikonogen or amidol give the most satisfactory results of all, the image having an extraordinary delicacy and beautiful colour.

Transparencies by Contact.—Transparencies may also be made by placing gelatino-bromide plates in contact with the negative in an ordinary printing frame, and exposing to light. Should a negative be feeble, if the exposure takes place through yellow glass better contrasts can be obtained. The best results are, however, obtained when the negatives are of good printing density. When feeble, camera printing is most suitable.

Transparencies by Contact with an Albumen Film on Glass.—The next method is one with which most beautiful transparencies may be produced, and although rather more troublesome than the processes which have been described, is well worth the attention of photographers who may have to make enlargements. The following are prepared:—

No. 1.—Good and ripe bromo-iodised collodion.

No. 2.—	Albumen from fresh eggs	10 ounces
	Acetic acid	$1\frac{1}{2}$ dr.

To prepare this, the albumen must be well stirred with a rod, and then allowed to stand twelve hours, when it is filtered through sponge or washed cotton-wool. Next, 40 minims of ammonia (·880) are added, together with—

Ammonium iodide	60 grains
Ammonium bromide	10 „

Dissolved in 6 drachms of distilled water.

This, kept tightly corked, and in a cool place, will remain fit for use for a couple of months.

No. 3.—Silver nitrate	480 grains
Acetic acid	3 ounces
Water	8 „

A clean glass plate (given a substratum, see page 260, by preference) is coated with No. 1 in the ordinary manner, and well washed under the tap. It is then coated with No. 2, which is allowed to drain away, carrying with it all superfluous water. No. 2 is again applied, pouring off and on from each corner in succession; and finally, it is allowed to rest on the plate for a minute, after which it is returned to the bottle. The plate is next set up to dry in a drying cupboard, standing on five or six thicknesses of blotting-paper. When thoroughly desiccated, it is *slowly*, and without stoppage, dipped into a bath of No. 3, and kept in it for from half-a-minute to a minute (a longer time than the latter is hurtful), and after withdrawal it is washed under the tap for a minute, and finally rinsed with distilled water. An examination of the film will now show if the plate is defective in any particular. Streaks may be removed by a tuft of fine cotton-wool soaked in water and applied gently. It is set up to dry in the drying cupboard, and care must be taken in this drying, as in the last, that it is not touched till thoroughly dry. It is now ready for printing, though a backing (see page 266) may be given it. When in contact with the negative it must be exposed for about fifteen seconds to the diffused light of a clear sky, or longer if the day be overcast.

To develop it, the following solutions should be prepared :—

A.—Pyrogallic acid	60 grains
Acetic acid	3 ounces
Citric acid	15 grains
Water	1 ounce

B.—Silver nitrate	30 grains
Water (distilled)	1 ounce

After removing the backing, wash the plate under the tap, and flow over it solution A and return it into the cup, in which have been dropped three or four drops of B. It is well to warm the developing solutions up to about 120° F., as then the image will begin to appear rapidly and evenly. In about twenty seconds the shadows should show, and it should be fully developed in three or four minutes. When any signs of streaks are visible, the plate should be washed and the cotton-wool tuft applied, after which the developing solution may again be flowed over the plate. When the details in the high-lights are sufficiently out, the plate is washed, and is ready for fixing and toning.

The following bath is recommended :—

Sodium hyposulphite	16 ounces
Water	22 „
Gold trichloride *	4 grains

The plate is allowed to remain in this bath fifteen or twenty minutes, according to the tone required (a brown tone requiring least time), and is then thoroughly washed for half-an-hour, and allowed to dry spontaneously.

The great difficulty in this process is the liability of the film to blister, but much depends on the kind of pyroxyline used in the collodion. A horny film is sure to blister, whilst one on which you can write your name with a pin without tearing the adjacent parts of the film will probably be found everything that can be desired. Cold in any stage of the operations is a great source of these blisters, hence all the solutions should be kept at a temperature not lower than 70° (21° *C.*). This remark applies equally to the fixing solution. If long parallel cracks are formed in the film whilst in the sensitising bath, the acetic acid is in defect; whilst streaks of unequal density are often due to plunging the plate too rapidly in it. A mottled appearance of the plate after sensitising is due to the film being too horny. This defect will not occur if the collodion be old, and sensitised, at least partially, with ammonium salts. An excess or defect in exposure is easily recognised by the appearance of the developed image. It is not a bad plan to make the exposure by artificial (such as gas) light of a known intensity.

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* This is best dissolved in two ounces of water, and added when dissolved.

Transparencies by Contact Printing, Collodio-Citro-Chloride, and Gelatino-Citro-Chloride.—Transparencies from dense negatives are better made by printing-out processes, as the gradation is better, as will be understood by comparing fig. 130, page 146, with the figures of density of prints. What is usually known as the collodio-chloride process may also be adopted. A glass plate should be albumenised round the edges, as for dry processes, and is coated with the collodio-citro-chloride. When dry, the film is fumed by holding it over the mouth of a bottle containing ammonia, and then moving it till the entire surface has received the vapour. The plate is now brought into contact with the negative in a pressure-frame. If strips of paper be gummed on to two of the corners of each plate, it may be examined without danger of loss of register during printing. A tolerable guess may be made of the progress of exposure by opening half the frame and looking through the two plates. It will usually be found that the print on the collio-chloride does not possess sufficient vigour. The necessary amount is given by flooding it with—

Gallic acid ...	75 grains ...	75 *parts*
Lead acetate ...	50 " ...	50 "
Acetic acid ...	2 drachms...	110 "
Water	20 ounces ...	8800 "

To this a few drops of a twenty-grain solution of silver nitrate should be added. When the intensity* is sufficient, the plate is washed, and then fixed with weak sodium hyposulphite. The image may be toned as given above.

Very beautiful transparencies can also be made by contact printing with gelatino-citro-chloride. Plates are coated with the emulsion as in the gelatine process, and printed deeply. They may be toned, but even when merely fixed they have a rich sepia tint which is not at all displeasing. The fixing bath is that given at page 181, omitting the alum bath.

Most firms of plate-makers issue special plates for lantern-slides. Some of these are suitable for making slides by contact, others by exposure in the camera, whereby the image on a large plate may be reduced to lantern-slide size. Other

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* The intensity increases on drying, therefore a certain allowance must be made.

plates may be obtained coated with a chloride emulsion, and yet others with a compound of bromide and chloride of silver, and Mr. Brooks of Reigate, Surrey, issues a lantern-plate coated with a print-out emulsion.

The plates coated with emulsions containing chloride of silver as ordinarily issued are too slow for camera exposures, and are only suitable for printing by contact. (If a boiled chloride emulsion, as given in p. 190, it may be used in the camera.) It is possible to obtain upon them images in a wide variety of colours by development only. The colours may be varied from a red orange through brown and purple to a blue-black, and may be varied still more by toning.

As each maker issues instructions with his plates, it will be sufficient to give one or two typical formulæ for developers.

Hydrokinone Developer for Black Tones.

A

Hydrokinone	160 grains
Bromide of potassium	30 „
Sulphite of soda	2 ounces (avoirdupois)
Water to make	20 „

B

Hydrate of soda	100 grains
Water	20 ounces

For use, take equal parts of A and B. Each ounce of the mixed developer will contain hydrokinone 4 grains, bromide of potassium ¾ grain, and soda hydrate 2½ grains.

Pyro Developer for Warm Tones.

A

Pyro	1 ounce
Soda sulphite	4 ounces
Water to make	80 „

B

Carbonate of ammonia	900 grains
Potassium hydrate	750 „
Ammonium bromide	600 „
Water to make	80 ounces

For use, take equal parts of A and B. Each ounce of mixed developer contains pyro 3 grains, carbonate of ammonia 5⅔ grains, potassium hydrate 4⅔ grains, and ammonium bromide 4 grains approximately.

In working for warm tones the plate should receive considerably longer exposure than for cold tones.

Chloride and bromo-chloride plates may be developed with any clean working developer, but the finest results are obtained with a well-restrained ferrous oxalate developer, or with the citrate of iron developer, when very warm tones are desired.

FERROUS OXALATE DEVELOPER FOR CHLORIDE PLATES.

A

Oxalate of potash...	16 ounces
Bromide of ammonium	320 grains
Water to make	64 ounces

B

Sulphate of iron	4½ ounces
Citric acid	½ ounce
Water to make	80 ounces

For use, one part of B is added to three parts of A.

CITRATE OF IRON DEVELOPERS FOR CHLORIDE PLATES.

A

Citric acid	2½ ounces
Ammonium carbonate	1 ounce
Water to make	10 ounces

B

Sulphate of iron	2½ ounces
Sulphuric acid	10 drops
Water to make	10 ounces

For use, take one part of B to three parts of A.

A clearing bath containing one part of sulphuric acid to 160 parts of water should be used after the ferrous oxalate developer.

Transparencies by the Carbon Process.—Another method of producing transparencies is by carbon printing. The gelatine is transferred to glass (which has had a slight trace of waxing solution rubbed over it) instead of to the zinc plate. The picture in this case will be reversed,* which is an advantage in mounting, as the ground glass protects the film.

Mounting Transparencies.—In mounting a transparency for a window decoration, some translucent substance must be placed behind it. Ground glass is usually employed, the rough surface being placed on the outside. Another better method is to dissolve to saturation white wax in ether. Filter, and to each ounce of solution add another ounce of ether. Flow over the reverse side, and allow to dry. After twenty-four hours the wax will give a beautiful transparency to the picture. In some of Breeze's transparencies a wax solution is poured over the film side of the positive. With all except the carbon and gelatine transparency the following may be substituted :—

Flake gelatine ...	... 2 ounces	... 2 *parts*
Glycerine ...	... ¼ ounce	... ¼ *part*
Water ...	... 6 ounces	... 6 *parts*

The gelatine should be allowed to soak in cold water till it is thoroughly swelled, and then dissolved by placing the vessel containing it in hot water. Just previous to use, two ounces of new milk heated to 90° F. should be added to the above amount; and the whole should be well stirred together with a glass rod, and sufficient of the mixture poured from a measure or jug through fine muslin to cover the plate, which must have been *accurately* levelled. It should be allowed to set, and then dried spontaneously in a warm room. If the transparency be reversed, the gelatine should be poured on the film side; and when thoroughly dried the film may be stripped off. The picture may be cut out and bent to any form after varnishing; for instance, lamp-shades may be composed of a set of prints thus produced.

If two hundred grains of zinc oxide replace the milk, we have Mr. Burgess's Eburneum process. The solution, with the

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* In producing transparencies in the camera, the same reversal may be effected by turning the film side of the negative away from the lens. The glass must be absolutely free from flaws to give a perfect result.

oxide added, should be kept warm, and allowed to stand six or eight hours before being allowed to solidify. The frothy top layer, and the bottom layer containing the coarse particles, are removed, and the solution is to be re-melted and poured on the plate as above. About four ounces of solution should cover a 12 by 10 plate.

Enlargements on Gelatino-Bromide Paper.—We have already shown the preparation of negative gelatino-bromide paper; we now come to the positive paper which is so much in vogue at the present time. In addition to the bromide and bromo-iodide paper, we may use gelatino-chloride. It may be boiled or not boiled, according as great or little sensitiveness is required. In any case, we like a paper which is only moderately sensitive, since there is no great need to take extremely rapid pictures. One thing, however, we may remark, that with bromo-iodide and bromide emulsions the colour resulting from a boiled emulsion has a tendency to be less green than one prepared without boiling. This remark also applies to gelatino-chloride emulsion, but not with so much force.

The emulsions may be prepared, and the paper coated, in the same way as given in Chapter XI, though it will require much less on the surface. For positive paper the amount of gelatine used may be much greater than when negative paper is being prepared; in fact, may be four or five times as much, and the emulsion formula should be corrected accordingly. Floating paper on a gelatine emulsion will cause it to take up sufficient for the development of a good positive print.

The paper to be coated should be thick Saxe paper, or paper of that description, with not too high a glaze on it. It should be cut up into the sized sheets required, and carefully dusted from every particle of dust. The emulsion should be heated and placed in a shallow dish somewhat larger than the sheet to be coated, and the fluid should be a quarter of an inch in depth. The dish must be kept warm by placing it on a closed shallow tin box containing water heated by a spirit lamp beneath, or some other similar means. When heated to about 130° F. (the temperature depending on the kind of gelatine employed), the paper is turned up for about a quarter of an inch at one end, and the sheet coiled up in a roll, the coil being made towards the turned-up end. The turned-up end is placed on the emulsion, and the coil gradually allowed to unrol itself till the whole surface, except the turned-up end, rests upon the emulsion. After resting a minute, the end is seized by two hands, and, a glass plate (to the front of which is fastened a wooden roller, the top on a level with the glass plate) having been made to rest on the dish, the uncoated side of the paper is drawn on to the plate, where it remains till it is set,* when it is hung up by clips to dry in a cupboard or other place free from dust. The paper thus prepared should present an even film, free from all tear markings.

When a bulk of emulsion is used (as it must be when paper is floated) a great consideration is to keep the whole of it homogeneous. If the temperature be high, the particles of bromide have a tendency to sink to the bottom of the vessel, and hence there is danger that a layer of gelatine may be at the top surface, which will contain but little of the sensitive salt. Hence, our advice is to keep the temperature of the emulsion as low as possible during coating the paper, consistent, of course, with keeping it fluid. A thick layer of gelatine is very unmanageable on paper. The paper, when drying, is apt to cockle, and unless a small proportion of glycerine is added, the film is apt to break and tear. About thirty drops of glycerine to the ounce of emulsion should suffice.

Contact Printing.—The following are directions issued for use with the Kodak paper:—Very thin negatives should be printed by weak yellow light, like that obtained from a kerosene lamp turned down a little below the normal intensity. In this way a strong, vigorous print may be obtained from a negative that would otherwise be too thin and flat. Strong, intense negatives are best printed by daylight.

The exposure varies with the intensity of the negative and the quality and intensity of the light, but may be approximately stated to be, using as thin a glass negative or film as will make a good print, one second by diffused daylight, or ten seconds at a distance of one foot from a Number 2 kerosene burner. A waxed paper negative requires twice as much, and an unoiled paper negative about three to five times as much exposure.

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* It is a good precaution to take to place a muslin-covered frame over the glass holding the gelatinised paper, to protect it from dust.

Enlarging.—For enlarging by artificial light, the negative should be thin and clear; but if daylight is used, the negatives should be bold and strong. If one has a weak negative to enlarge by daylight, a strong print may be obtained from it by varnishing the back with ordinary negative varnish slightly tinted with a yellow aniline dye. Where many such negatives have to be treated, separate glasses tinted to various shades of yellow may be employed, one of these glasses being put directly behind the negative, between it and the source of light. Only a very slight yellow tint is required to increase the contrast in the resulting print to a marked degree. The Kodak Company issue bromide paper for enlarged prints, which give excellent results in every way. Messrs. Wellington and Ward's papers are also very fine, as we can personally testify. Their negative paper is also of the highest quality. There are other papers to be obtained, but the writer cannot speak from personal trial of them.

Development of the Positive Paper.—For prints on bromide paper, a glossy surface is a mistake if the colour approaches a black, since it then more or less imitates the colour of an engraving, and should have a somewhat similar appearance. There are several papers on the market which have a matt surface, and these, when developed by amidol (see page 170) or ferrous oxalate, give a dead black colour, and furnish prints which are indistinguishable from a very fine platinum print; for this reason we recommend these developers, especially the amidol. There is often some difficulty with ferrous oxalate, in keeping the whites from yellowings, owing to minute quantities of the iron salt being left in the paper even after thorough washing. It should be remembered that in developing a positive picture, there should be points of absolutely pure white in it, and hence development should not be carried too far. We do not think that the tones which endeavour to imitate prints on albumenised paper are to be desired; artistically a black tone is certainly preferable, though, it may be, the public taste requires to be educated to view the matter in this light. The ferrous oxalate developer given at page 179 should be used. One part of No. 1 may be mixed with six of No. 2, and half the quantity of water added. To obtain great purity in the whites, to every ounce of developer 20 drops of a (20 grains to the ounce of water) solution of bromide of potassium should be used. Before fixing and before washing, the print should be immersed in a bath of acetic acid and water, 1 part to 200. After washing, it is fixed in—

Sodium hyposulphite	3 ounces	3 *parts*
Water	20 ,,	20 ,,

This should be renewed if it is at all yellow.

The merest trace of hyposulphite from the hands when using the developer will spoil the purity of the whites, and great care should be taken to avoid any such contamination.

As an alternative to the ferrous oxalate developer, metol, amidol, or indeed any of the more recently introduced developers mentioned in Chapter XVI. may be used. We prefer amidol on the whole, as the tones are black and grey. With these developers the clearing bath is unnecessary; but the acid fixing bath mentioned in Chapter XXI. may be used with advantage.

Should a browner tone be desired, it may be given, after development, by a weak solution of ammonium sulphide, the colour being permanent. All excess should be well washed out. A solution of sulphuretted hydrogen in water will answer the same purpose. Against the use of such solutions we are aware that many photographers will, metaphorically, hold up their hands, as they will remember the dread they have of bringing any sulphur compounds in contact with a print on albumenised paper. They should recollect, however, that the conditions are totally different. It is the organic compound of silver which gives rise to fading, and not the sulphuration of the metallic silver. Sulphide of silver is about as permanent a silver compound as can exist, and there can be no danger of its fading. Great care must be taken to eliminate all traces of iron salts if the development takes place by this means, by washing after development, when using the above solutions; otherwise the white will be dirty. The tone assumed by the prints with this treatment is a warm brown-black, reaching a jet-black if prolonged.

Enlargements on Albumenised Paper.—Most excellent results can be obtained by taking an enlarged transparency on a gelatine plate or on bromide paper, and then printing out a negative image on ordinary albumenised paper (see chapter on silver printing). The printing should be carried beyond that usually adopted, as every detail should be plainly visible. The negative print thus obtained should be simply fixed, and, when washed and dried, should be waxed, as described at page 201. Prints from these negatives are usually soft and full of detail, the grain of the paper usually adding to the artistic effect.

Mounting on Card.—Permanent bromide prints should be mounted dry; that is, the prints should be allowed to dry before pasting; they should *not* be dried between blotters like albumenised paper, but should be hung over a line, or laid back down upon glass or clean paper. When dry, brush over the back with thin starch paste, lay the print on to the mount, and rub into contact with a soft cloth.

For burnishing, the print must be quite dry, and a dry lubricator used, Castile soap answering for that purpose.

Cloth Mounting.—Enlargements are usually mounted on cloth-covered strainers, as follows. Take a frame, such as artists use for stretching canvas, and cover it with common white cloth; put the cloth on dry, stretching it tight, and tacking along the edges. Lay the dry print face down on the table, and brush over the back with thin starch paste; let the print lie until limp; give the cloth on the strainer a coat of paste, and then lay it down upon the print, and rub the cloth into contact with a soft rag; rub under the frame with a paper-knife; do not rub the print down from the face, or the inside edges of the strainer will show through. When dry, the print will be stretched smooth and tight.

Enamelling.—Prints on smooth paper may be given a beautiful polished surface, superior to that obtained by burnishing, in the following manner. Sprinkle the surface of a glass plate with powdered French chalk, rub it evenly over the surface with a tuft of cotton-wool, continuing to lightly rub it until the chalk is all removed, then coat the glass with the following collodion :—

Soluble gun-cotton ...	48 grains ...	1 *part*
Alcohol	4 ounces ...	10 *parts*
Sulphuric ether	4 „ ...	10 „

As soon as the collodion is well set, slide the plate face up into a tray of water, in which is floating, face down, the permanent bromide print, which has just been fixed and washed; grasp the plate and print by one end, and lift together from the water, avoiding bubbles, and draining the water from the opposite end; squeegee the print into contact with the plate, and set away to dry. Before the print is quite dry apply a coat of starch paste to the back. After drying, the print can be peeled off from the glass, and the face will present a polish almost as high as the surface of the glass from which it had been removed. The print is then ready to mount, as follows. Moisten the face of the mount with a damp sponge, and lay upon it the print; rub down with a soft cloth, and put under pressure to dry.

Another method is to squeegee the wet print, face down on a polished piece of hard rubber or ebonite; when dry, the print will peel off with a fine polished surface. The print should be slipped on to the rubber plate under water to avoid air-bells.

Flexible Prints.—Permanent bromide prints soaked in a mixture of glycerine 5 ounces and water 25 ounces, and dried, will not curl, and may be used for book illustrations unmounted.

Straightening Unmounted Prints.—After drying, prints may be straightened by the scraping action of a sharp-edged ruler applied to the back, the corner behind the ruler being lifted as the ruler is passed along.

Chloride Positive Paper.—In the market there are several brands of rapid printing paper for development. Most of them are gelatino-chloride papers; some, however, have mixtures of bromide with them. The advantage of these brands of paper is, that they may be developed and then toned.

We have prepared paper which answers every requirement by the formula given at page 190, using three times the quantity of added gelatine. It is preferable that it should be unboiled, or, at all events, only very slightly boiled, in order to get a warm tone.

The following developer is recommended:—

No. 1.—	Potassium oxalate ...	125 grains ...	125 *parts*
	Potassium bromide ...	5 „ ...	5 „
	Water	1 ounce ...	440 „

No. 2.—Ferrous sulphate	...	50 grains	... 50 *parts*
Water	... ...	1½ ounces	... 650 „

Three parts of No. 1 are mixed with one part of No. 2, and two* ounces of water.

The longer the exposure within limits, the more warm is the tone produced; a warm tone is not produced if the exposure is short. An exposure of half a minute in diffused daylight should be sufficient to give a warm tone. The image should be developed till it appears rather darker than it should finally be. It is next well washed, and then placed in a saturated solution of alum, where it is left for a quarter of an hour. It is taken out and washed for a quarter of an hour, when it may be toned. The following toning bath (the *sel d'or*) is recommended :—

A.—Hyposulphite of soda ...	30 ounces	...	3 *parts*
Water	30 „	...	3 „
B.—Gold chloride	3 grains	...	3 „
Water	4 ounces	...	1760 „

To every 7½ parts of solution A add 1 part of B slowly, stirring well. The bath is then ready for use. It improves by keeping, and, when necessary, is replenished by the addition of fresh hyposulphite of soda, and of gold solution B.

The print is to be kept in this bath for ten minutes, when it will be both toned and fixed.

The following acetate of soda toning bath also answers well :—

Gold chloride ...	1 grain	...	1 *part*
Acetate of soda ...	30 grains	...	30 *parts*
Water	8 ounces	...	3500 „
Chloride of lime	...	...	... *a slight trace*

The lime toning bath and the borax bath (see Chapter XXXIX.) may be used.

After the print is toned in any of the above baths (except the *sel d'or*), it must be fixed in a two per cent. solution of hyposulphite of soda.† It is again washed, and then dried in

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* Some recommend two ounces of a five per cent. solution of sodium sulphite to replace these two ounces of water.

† Mr. Ashman found, we believe, that if the prints, before toning, were

contact with some smooth, flat surface. It was originally recommended to use a glass surface which had been rubbed over with powdered talc, but we have found that the gelatine was liable to stick to the glass. If the glass be rubbed over with castor oil, however, it may be used, and a fine surface is given to the print. Perfectly smooth ebonite or ferrotype plates may also be used. A print after washing is placed, face down, in a dish, with the surface to which they are attached beneath. The two are raised out together with a layer of water between, when a squeegee is brought to bear on the former, the water squeezed out, and the two surfaces brought out into close contact. They are then placed to dry, and when desiccation is perfect the two can be detached. The mounting of these prints is somewhat difficult, on account of damp spoiling the gloss of the surface. Mr. Warnerke finds that if the prints are to be burnished, sufficient surface is given to the prints, and there is no need to dry them in contact with the support.

For direct enlarged positives, the thinly-coated paper is extremely useful; an optical lantern can be used, and good prints secured with but very short exposure. As an example of the exposure necessary for this, we have produced an enlargement of six diameters by an exposure of three minutes when using a triple-wick oil lamp as the source of illumination.

A number of printing papers have recently been placed on the market, under the names of Velox, Dekko, Gravura, etc., upon which black tones may be obtained by exposure to gaslight, or warm tones by longer exposures which are best given by daylight. These papers require to be developed, but as they are only feebly sensitive to artificial light, development may take place at a few feet distant from an unshielded gas-flame or oil lamp. With the longer exposures, colours ranging from orange through red and brown to purple may be obtained. Each maker issues special formulæ for use with his paper.

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immersed in a weak solution (say half per cent.) of ammonium sulphocyanate for a short time, the toning colour was more satisfactory.

CHAPTER XXXIII

ARTIFICIAL LIGHTING

At page 306, some results of the photographic value of different sources of light have been given in terms of a standard candle. The question of photography by night involves a knowledge of what light can be best used, and a reference to the table given will be of some use.

Flash-Light.—The first light to be mentioned is the flash-light. A flash-light consists essentially of magnesium powder, or of magnesium powder mixed with strongly oxidising substances, blown through a burning jet of some description. There are a large variety of flash-lamps in the market, and a reference to the catalogues of dealers will supply information regarding them. The use of oxidising substances with the magnesium powder has led to accident, and it is doubtful if the mixtures can be rendered so safe as to allow them to be recommended. Dr. Eder has found, for instance, that $\frac{1}{2}$ a gramme of a mixture of 30 parts of potassium perchlorate, 30 parts of potassium chlorate, and 40 parts of magnesium powder, burnt in from $\frac{1}{20}$ to $\frac{1}{80}$ of a second. The former velocity is sufficiently safe for all purposes, since the jet of air propelling these substances will travel at a greater rate than this velocity of ignition, but if the shorter time be taken, it is quite possible that the rate of combustion will be such that it is more rapid than that of the air propelling them into the flame, in which case an explosion in the air passage might take place. Half a gramme of magnesium powder blown from the mouth took $\frac{1}{2}$ to $\frac{1}{8}$ of a second to burn, according to the lamp in which ignition took place. This is a safe rate of combustion. It should be recollected that in the mixtures of powder with the magnesium an explosive mixture is prepared, the ignition being analogous to that of gunpowder. If, however, oxygen be the medium by which the magnesium powder is blown through the flame, this does not obtain—at all events, to so large an extent. The intensity and rapidity of oxidation is, even with it, so much increased that the light becomes whiter, more blue rays being present in it, and consequently the photographic effect is much stronger. A measurement made by the author showed that the effect of burning one grain of magnesium ribbon in oxygen was equivalent to burning from six to twelve grains of the same ribbon in air, so far as photographic action was concerned. A light, therefore, in which the propulsive power was a stream of oxygen should certainly be more effective than one in which air alone was used. If a bladder full of oxygen be attached to the flash-lamp so as to replace the india-rubber ball, an excellent light is produced on pressing it.

All photographs of objects taken with a single flash-light are subject to the great defect of sharply cut and black shadows. If reflecting screens are used, this last defect is mitigated to some extent. The reason why the shadows are thus sharp and heavy is, that the light proceeds from a single source instead of being diffused, as it is in daylight. To overcome this difficulty, ingenious arrangements have been made by which several flash-lights may be ignited at the same instant by means of connecting tubes. One blast, caused by the pressure of the hand on the rubber ball is sufficient to send the magnesium powder through the connected-up lamps, but even in this case there are cross shadows which mar the artistic character of the production.

Magnesium in Oxygen.—Mr. E. Humphery, of the Platinotype Company, has shown a plan by which cross shadows are avoided, and by which the light is diffused over a large area, and in consequence the shadows cast, though single, are not sharp, and are, to a certain extent, illuminated. He fills a glass flask of about seven inches diameter with oxygen, and corks it up preparatory to the insertion of magnesium ribbon or wire, which he coils up in the form of a cylindrical spring, attaching to one end a cap which will just fit over the mouth of the flask, and to the other he attaches a short bit of twine. The flask he attaches by a string to the ceiling, or to a cord stretched between two walls, so that it can swing freely; and when the camera is in position, he lights the twine end of the magnesium wire, takes out the cork from the flask, inserts the ribbon, and sets the apparatus swinging some six or eight feet. The oxygen keeps the string alight, and this finally ignites the magnesium wire or ribbon, and the exposure is thus automatically made. As the magnesium takes a second to burn, the light, while giving a general illumination, appears to cast no harsh shadows. Six inches of ribbon, or some 2½ grains of magnesium, emits sufficient light during its ignition to illuminate a sitter placed some nine feet from it. The light from the burning magnesium is, of course, not permitted to fall upon the lens. Excellent portraits can be taken by this contrivance in an ordinary room, and it has the advantage that all the smoke, due to magnesia, remains in the flask. The light is sufficiently strong for printing on platinum paper. An expenditure of some twelve grains at six inches distance from a negative will give a fully exposed print, and the time of combustion is small.

The Platinotype Company now sell a lamp constructed to give a continuous light with magnesium and oxygen.

Nadar's Lamp.—A lamp which is but little known in England—Nadar's lamp—enables a continuous flow of magnesium powder to be forced through a powerful upright flame of a spirit lamp. The writer has made a slight modification to it, by placing round the blow-through tube an outer tube through which a stream of oxygen is forced at the same time that the air is carrying the magnesium powder through the flame. Ignition of twenty grains of powder by this means is found to be sufficient to illuminate objects twenty-five feet distant when a rapid plate is used, with an aperture of the lens of *f*/11. It requires four or five times that amount when the air alone is used. This plan adopted of utilising oxygen renders the ignition absolutely safe, and is on the same principle as the blow-through jet of an oxy-hydrogen lamp. With this lamp, about 120 grains per minute (or 2 grains a second) are used when the blast is continuous, and this amount, when the lamp is placed six inches from a printing frame, suffices to give a fully exposed platinum print. One advantage of this lamp is that it may be carried about during ignition, so that the extreme hardness of shadows is avoided.

When using magnesium, the lens may with safety be uncapped, and the slide drawn up a few minutes before the exposure has to be made.

The Use of the Electric Light is open to fewer of our readers than the magnesium light, and therefore need not be entered into with very great detail. Its fault is the sharp shadows it casts, unless it be hidden from view and reflectors used. Van der Weyde, who—in this country, at all events—was the pioneer in using the electric light, has adopted a spherical reflector of considerable size, coated with a dead-white material. The hottest part of the carbon points is turned towards this reflector, and the only light reaching the sitter is that coming from the reflector; hence the shadows are illuminated, and splendid effects can be obtained. For portraiture, he suspends the lamp and reflector, and, by an ingenious mechanical arrangement, he can throw his light in any required direction.

Various forms of apparatus for use in the professional portrait studio can now be obtained. The incandescent electric light and acetylene gas are both used. The apparatus takes the form of a spherical or parabolic reflector painted a dead white inside. The electric lamps are arranged round the periphery of the reflector; or, in case of acetylene gas, a bracket carrying the jets is supported in the reflector. Generators for producing a supply of acetylene gas are sold with the apparatus, which can thus be used in villages and country districts.

Lighting by Candle-light and Gas-light.—This can be readily calculated from the table at page 306. In this case, calculating back from the light emitted by magnesium, it will be seen that, when fairly illuminated, photographs of a room or dark interior can be obtained. Beware, however, of having too much light in the lens itself, and in case a light is in the picture, a plate should be used which is properly backed to prevent halation.

Acetylene Lighting.—It has often been assumed, but without proof, that the light from acetylene is much more "photographic" than is gas. The writer has made very careful experiments, and he finds that if the optical values of a gas-light and an acetylene light were equal, about double the amount of photographic action will be produced. The great value of acetylene is in the fact that the light itself is much smaller in area of flame than the gas, when equal illumination is produced.

Incandescent Gas-Lighting.—The nature of the light in the incandescent gas-light is manifestly different from that of the ordinary gas-flame. The light is produced by the heating of the mantle of rare earths which are used to form it. The result is that the light is greener and bluer than the ordinary gas-light, and, as such, has more "photographic" value than the latter when the optical values are the same. It is perhaps as much as twice as powerful photographically than visually. It also has the advantage of being a steady light of not too large dimensions. For this reason it is valuable for illuminating purposes when photography is to be employed.

CHAPTER XXXIV

ORTHOCHROMATIC PHOTOGRAPHY

THE question of orthochromatic photography is one which has in recent years occupied the minds of photographers, and a good many rash statements have been made concerning it. In this chapter we will endeavour to discuss what can actually be done at the present time regarding it, and what cannot.

Orthochromatic photography means, in its strict sense, rendering in right colours an object by means of photography; but it has come to mean rendering a coloured object in monochrome in correct monochromatic tones. That is to say, to represent the brightness or luminosity of colours correctly in monochrome. This refers to the spectrum colours of course as well as to other colours, and if we can represent the former correctly, we can, *à fortiori*, represent the latter. At page 44 we have a representation of the spectrum in brightness, the heights of the ordinates above the base-line representing their luminosity at any point. It will be seen that whilst the luminosity of the yellow is nearly 100, that of G is about 1. Turning to figure 5, page 12, the photographic representation of the spectrum on an ordinary bromide plate, we see that the luminosity of G is not far short of 100, whilst at D it is so small as to be unrepresented. It is evident then that a photograph on an ordinary plate falls very far short of what is required. We can, however, by an artifice, use the ordinary plate, and this we will consider first. If we place a cell of chromate of potash in front of the spectrum, we find that by an exposure exceedingly prolonged we can obtain an impression of the spectrum to the extreme red, including the green and the yellow. With this prolonged exposure we get a negative which very fairly represents, by its opacity at the different parts, the brightness of the spectrum at the different regions, for a print taken from it will shade from white in the green to black in the extreme red. The green will still be the brightest instead of the yellow. Substituting bichromate of potash, we get something rather better, but the green and the blue will be represented in the negative as a blank, and therefore in the print would show as black. By mixing the two, the green, yellow and red can however be got fairly correctly represented, but the blue will be absent. There is a dye in the market which is called brilliant yellow that may be substituted for it, and this has the advantage that a thin microscopic glass may be coated with it by mixture in gelatine or collodion, and this may be inserted at the diaphragm of the lens in a small cardboard. The other side of the microscopic glass may be coated with a very weak solution of fuchsine in gelatine, and the green will be dimmed, whilst the red and yellow remain nearly unchanged, but the blue will be missing. If, however, a small pin-point of the brilliant yellow coating be removed, a certain very small quantity of white light will penetrate to the plate, and impress the blue of the spectrum, and by trial the spectrum itself may be fairly represented. When this is attained, the coloured objects in nature will be correctly represented in monochrome by the use of such a coloured diaphragm.

There are various samples of plates in the market which are said to be "orthochromatic," or "iso-chromatic," and examples of these are given on pages 14 and 16, where the spectrum of gas-light has been photographed with them without any screening by coloured media. These plates are very far superior to the ordinary plate in sensitiveness to the yellow and orange of the spectrum, but there is always an inferiority of sensitiveness in the green, though in one sample of the Cadett spectrum plate the inferiority is very small. Such plates can be used successfully for approximately correct rendering of colours in monochrome by an artifice. Every colour in nature is a mixed colour, that is, includes fairly large portions of the spectrum, and this inferiority in sensitiveness for certain small portions of the spectrum rays may be made up by superior sensitiveness of adjacent parts of the spectrum which such mixed colours include. By means of a sensitometer first introduced by the writer, prepared with coloured glasses, we can obtain a substitute for the spectrum. These glasses have the advantage of transmitting colours which are mixed colours, and the balancing, as it were, of the excess of one spectrum ray with the defect of another, can be thus carried out. The principle of the sensitometer is easy to understand. If we take a white, a red, a yellow, a true green, a blue-green, and a blue, we have a representation of the principal spectrum colours. If a plate be simultaneously exposed to light coming through it, and if by the different opacities of the negative the print is obtained which represents them by their true luminosity, we have very approximately solved this, the problem as to orthochromatic work. To ascertain this, however, we should have to measure the brightness of the light transmitted through the glasses, and also measure the densities of the negative. A simpler plan is, however, to reduce all the light coming through the glasses to equal luminosity. The source of the light which is transmitted must be the same as that in which the sensitometer would be used in trying the plates. Most photographers would prefer to use the sensitometer with an artificial light such as gas-light. The luminosity of this light transmitted through the different glasses is measured either by placing them successively behind a screen, as figured at page 135, and altering the light in front till the two squares A and B appear of the same brightness, or else directly by using two gas-lights with a rod in front of a small white screen, and equalising them by the Rumford plan, and then inserting in succession the coloured glass in front of one of them, and equalising the brightness of the shadows. In the first case a piece of glass, ground on both sides, should be substituted for the paper to avoid the selection or absorption by the paper of any rays. The luminosities of the coloured rays are then known. If small portions of Kodak films are exposed for varying times to white light and developed, and the opacities measured, some will be found which, when superposed over the different glasses, will bring all to a uniform luminosity. The blue will be that which will require no shielding, and the white the most. Half-inch squares of the glasses may be made and ranged in a row as in the figure, mounted on white glass, with Canada balsam, and surrounded with a black mask as shown, the proper densities being cemented on the other side of the blank glass, also masked with black paper. When viewed in gas-light, all the six squares will appear of the same brightness. But it must be remembered that they will appear of unequal brightness if viewed in daylight or in the electric light. When such a sensitometer is placed on a sensitive plate, and gas-light, filtered through a proper screen, falls on it, the opacities should be exactly equal. Such a sensitometer is one which avoids constant measurement of opacities, and can be used for all plates. The screens through which the light filters must be altered for each class of plate till the end wished for is secured. Suppose, for instance, the screen used with a certain plate makes the opacity beneath the green and green-blue too great, some screen must be added which will cut off a small portion of the green, such as dilute fuchsine, and so on.

Fig. 153.

It is not immaterial what the colours of the glasses in the sensitometer are. We recommend that the red should be "stained red," with a yellow glass added; the yellow, a canary-yellow; the green, chromium-green and signal-green combined; the blue-green, two thicknesses of signal-green; and the blue, cobalt-blue and signal-green combined. These give different small portions of the spectrum, which overlap; but the red will not allow any blue rays to pass, and the green will not contain red rays, nor will the blue. If both ends of the spectrum are transmitted by the blue and the red glass, false conclusions may be derived from the use of the sensitometer. It may here be stated that when a screen is found which will give orthochromatic effects with gas-light, the same screen will be equally effective with any other light, such as daylight, sunlight, incandescent gas-light, or any light which gives a continuous spectrum.

It is often stated that the screening to obtain perfect results on an isochromatic plate is such as only to increase exposure by some five or six times; but if perfect effects are to be obtained, it will be found that the exposure has in reality to be prolonged fifty or sixty times, the effective screen cutting off that proportion of light. In other words, the exposures necessary for a gelatine plate are increased to twice that which were formerly given in the ordinary wet plate.

There is another plan which the photographer may adopt if he dislikes working with candle-light. Let him take vermilion, emerald-green, and French ultramarine (French blue), and chrome-yellow, as his standards. The French blue will be the darkest of the colours, and that may be mixed with a little size and painted on a piece of card. Take the chrome-yellow and mix lamp-black with it in varying proportions, when he will find a tint which, when illuminated, will give him a depth of tone which will be the same as the blue. The colour will appear a dirty yellow-green, but he can satisfy himself that the colour is really the same by examining it in sunlight, or throwing the electric light on it, when the colour will appear of the same original yellow. The same procedure may be taken with the red and the emerald-green. The white must also be toned down to a grey by mixing lamp-black and chalk together with size. These colours may be painted thickly on cardboard, placed side by side on a board and photographed, different screens being used till they all give the same density. To avoid making the colours too dark, the blue may be mixed with a suspicion of white.

There is yet another plan which may be adopted, and this plan lends itself to a still further knowledge for seeing what change in the screen is required.

Cut out two blue discs in a card, as in fig. 154, A, and also a black, a red, a yellow, a white, and a green, of the intermediate size; cut a slit radially in each of the colour discs (except the blue) and the black disc so that any sector of colour can be covered by the black disc by slipping one disc inside the other. On a spindle, which can be caused to rotate rapidly, first place the large blue disc, then one of the colours with the black disc partially covering it, and finally the small blue disc. Make the spindle rotate, and the colours and the black will blend, and the eye will at once see whether the mixture is darker or lighter than the blue. If too light, add more of the black, and if too dark, less of it. Note the angular amount of black added. Change the colour, and do this for all, including the white, of course. Then on a card form a diagram, such as is shown in fig. B, using the same proportions of black to colour as was found by the total discs, and rotate it round the centre by placing it on a whirling machine. Y, G, R, etc. show different colours, and the black mixed with them. The colours will be now of equal luminosity, and the photographs of each should show of equal density when the proper screen is arrived at. It may be noted that the hue proper for painting the cards by the previous process can be obtained by this method, remembering that the colour may differ in depth when dry from what it appears when moist. The glass sensitometer appears to be the most convenient form, and the writer prefers it. It may be graduated for daylight, if preferred, by using the screen which is figured at page 137, at the end of a box, placed against a window, and balancing the luminosity by a candle in the box as before. A very direct way of graduating is to place the pieces of glass in square apertures in a black mask, say $\frac{1}{2}$ inch wide, and to move a graduated strip of film behind the brightest till the two appear equally bright. The part of the film which gives the necessary darkening may be used in the sensitometer itself. The match for luminosity should be made several times, and the mean of the density used. The squares should be as close together as possible. The stereoscope may also be employed. Let there be a card placed in the stereoscope with two small holes punctured in the centre of each half. The eyes will see these two points as one image. If a square

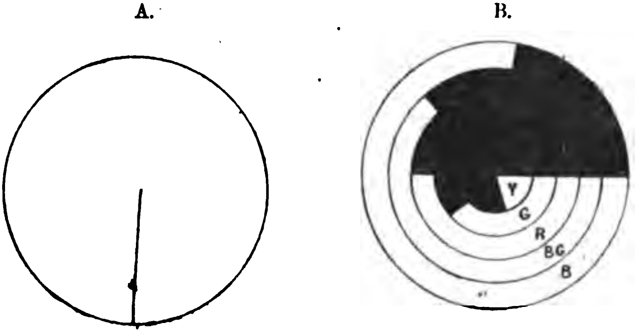
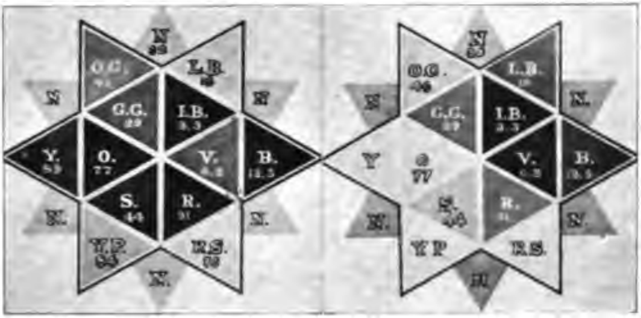


Fig. 154.

N is Neutral Tint.
O G is Orange Chrome.
L B is Light Blue.
I B is Indigo Blue.
C G is Chrome Green.
Y is Yellow.
O is Orange.
V is Violet.
B is Darkish Blue.
S is Salmon Colour.
R is Red Vermilion.
Y P is Yellowish Pink.
R S is Reddish Salmon.



To face p. 339.

Fig. 155

The visual luminosities of the colours are shown beneath the initial letters of the colours.

aperture be cut on each side of these holes, on the right side in one case and on the left in the other, and they be covered with the glasses, it will be found that each eye will see one image, one colour with one, and the other with the other, and they will appear side by side. The two brightnesses can be equalised as before.

A sensitometer graduated for daylight should be exposed in front of a plate in the camera with a lens pointing to a grey sky, or to a sheet of white paper illuminated by the sky. Fig. 155 shows a coloured chart, photographed with and without Cadett's screen.

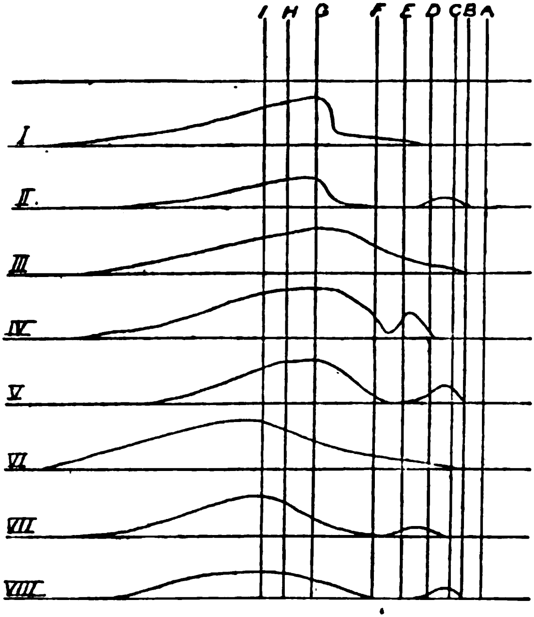
In the second chapter of this work, we have alluded to the action of light on silver salts which are in contact with certain dyes, and have briefly given the theory which seems to apply to this action.

The main facts are these: that when certain fugitive dyes absorb in a part of the spectrum to which the silver salt is insensitive or only slightly sensitive, the rays absorbed have a secondary action on the silver salt in contact with them, either producing sensitiveness, or increasing the sensitiveness. If the silver salt combines with the dye, the action is readily explained by the ordinary theory; whilst if it does not, the dye itself undergoes alteration, and becomes, as it were, a developer, reducing a small portion of silver salt, on which subsequent development takes place.

There are numerous dyes which are effective in giving a certain amount of sensitiveness to parts of the spectrum which are ordinarily inactive. Cyanin blue, which is a definite chemical compound, and the fluorescin derivatives (eosin, erythrosin, etc.), are those which are most generally used in practical photography.

The first-named dye absorbs in the yellow and the orange, and a little in the red, and therefore gives sensitiveness to these colours, whilst the second class absorbs in the green and green-yellow, and gives sensitiveness to these colours.

Fig. 3 and the diagram on the next page will give an idea of the spectrum value of negatives taken on the erythrosin and cyanin dyed plates, and the diagrams in Chapter II. should also be consulted. It will be seen how very far from fulfilling the conditions laid down any of these dyes or their combinations are capable of doing.



I. Spectrum on Silver Iodide.
II. Spectrum on Silver Iodide and Erythrosin.
III. Spectrum on Silver Bromide.
IV. Spectrum on Silver Bromide and Erythrosin (with excess of silver).
V. Spectrum on Silver Bromide and Cyanin.
VI. Spectrum on Silver Chloride.
VII. Spectrum on Silver Chloride and Erythrosin.
VIII. Spectrum on Silver Chloride and Cyanin.

A mixture of malachite green and naphthalene blue (indophenol blue) also gives sensitiveness to the red, yellow, and green, diminishing that for the blue, whilst cœrulin S acts as a sensitiser to the red.

Orthochromatic plates are principally useful for photographing pictures or for spectrum work, and are not of much advantage for landscape or portrait work. In a landscape, objects, whilst reflecting local colour, reflect a large proportion of white light, for reasons which it is not hard to see when it is considered at what an infinite variety of angles their surfaces are presented to the light, and that it is only when the light falls perpendicularly on the surface that the minimum of white light is reflected. The best chance of obtaining an approximation to true luminosity is to interpose some coloured screen between the object and the plate. Various coloured bodies may be used, depending on the object to be photographed. For a wooded scene in early summer, for instance, a bottle-green glass will be appropriate, whilst for autumn tints, where yellows and reds prevail, and are brighter than the unfaded leaves, an orange glass may be employed with advantage. These glasses cut off the blue and violet, and leave the brighter colours alone to act on the plate, and the white reflected light is reduced in activity, allowing the local colouring to impress its luminosity.

Light diffused through and reflected from cloud is of very much the same character as sunlight. On a day in which a landscape is illuminated by skylight as well as by sunlight, the shadows of objects will be principally illuminated by blue skylight, and the white light reflected from these shadows will be principally of skylight quality. If an orange glass be interposed between the lens and the landscape, it is manifest, by a reference to fig. 22, page 44, that the shadows will be relatively more dimmed than the high-lights, since the former reflect light more blue than the latter (see fig. 24, page 46); hence a picture will be harsher. For the very same reason, when photographing clouds on a blue sky, the latter will appear almost black, whilst the former will be bright. Again, too, when there is blue haze in a distant landscape which is due to the scattering of small particles in the atmosphere, the blue light of the haze will almost disappear, whilst the sunlight from the distant objects will appear nearly unaffected. Thus, for scientific delineation of cloud, and for eliminating one of the chief charms of a landscape on a summer's day, the use of yellow glass is a desideratum.

In early spring, when the greens are very light, there is an advantage, though slight; but we believe that the ordinary plate, even under these circumstances, will give a more pleasing picture than the orthochromatic one. When sunlight is very yellow an ordinary plate will often fail to show any distinction in luminosity between the sunlight and the skylight parts of a view, owing to the insensitiveness of the silver compound to the quality of sunlight illuminating it. In such a case the advantage is distinctly to be found in favour of an orthochromatic plate, when means are taken to reduce the blue light falling on it.

In copying pictures, the kind of light illuminating them is usually under control, and excellent results can be obtained by using gaslight as the illuminant, even without a yellow screen. Fig. 24, page 46, shows that the blue rays are very largely deficient in gaslight, and hence the reason of the superior result. The author now often uses gaslight reflected from an orange-coloured concave reflector made of paper. The reflecting surface is coated with orange chrome. The gaslight (or electric light) is placed at a distance of half the radius of the sphere of which the reflector is formed, and direct light may be cut off by an opaque screen. Another plan is to illuminate the painting by light coming through canary-coloured glass. In this case sunlight or the electric light may be used.

Colour-Sensitising Ordinary Plates.—We will now give directions for rendering an ordinary plate orthochromatic for the green and yellow with erythrosin or eosin. The formulæ are those given by Mallmann, and none better have appeared since they were first published, though the subsequent washing, to be described later, appears advantageous.

After having dusted the plates, they are passed through the following bath, where they are allowed to remain two minutes:—

Ammonia	2 parts
Distilled water	200 ,,

Afterwards the plates are dipped in a bath having the following composition:—

*Erythrosin or eosin (1 : 1000 of water)...	25 parts
Distilled water	175 „
Ammonia	4 „

and kept in this for one minute to one and a quarter minutes. Mallmann then directs that the plates are to be allowed to dry in the dark after draining. The final draining is best done on a porous tile. These operations should be carried out in a deep red light, and not too much of it. The baths should always be covered.

It must be pointed out that there are a variety of eosins in the market, some of which are very inferior in giving colour-sensitiveness. Erythrosin is, however, very safe to use. When pure it should exhibit no fluorescence, and a nearly total absence of this phenomenon indicates that its purity is sufficient for the purpose. The plates, when thus prepared, are a salmon colour, and, according to Mallmann, they are in the most sensitive state. It will be found, however, that if they are washed so as apparently to eliminate all colour, they will be equally colour-sensitive, and there will be no tendency to markings, which there is if the stain be allowed to remain, even after most careful draining.

Plates prepared by this plan have a considerable amount of sensitiveness to the green-yellow, though not to the red.

Mallmann recommends the ordinary alkaline pyrogallic acid developer for these plates, but the writer has found that any developer given in Chapter XVI. may be used, as may also the ferrous oxalate developer.

If the plate after washing, however, be allowed to dry, and be then plunged in a bath of cyanin—

Cyanin	1 part
Alcohol	100 parts
Water	9000 „

and be allowed to soak in it for two minutes, and if it be again washed, first with a ten per cent. solution of spirit and water, and then with water alone, till all greasiness disappears, it will be found on exposure to be sensitive to the orange-red as well

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* When cyanin blue is used in combination with either eosin or erythrosin, the above bath is made, and 5 parts of an alcoholic solution of cyanin (1 : 1000) are added.

as to the green (see fig. 8, p. 15). The plate may be dried, but there will be a greater tendency to fog than if used whilst still moist.

When cyanin is used, it is always essential to use more bromide in the developer to keep the negative clear, as it has a tendency to cause fog. Three times the quantity which is used for ordinary plates will usually suffice.

Preparation of a Green-Sensitive Gelatine Emulsion.—The ammonia process given in Chapter XI. is most suitable when eosin or erythrosin are to be used in the alkaline state—*i. e.* with ammonia. It suffices to add 1 part of erythrosin or eosin dissolved in water to every 500 parts of the emulsion before washing. It may then be washed as usual. In case a boiled emulsion be used, the dye should be rendered slightly ammoniacal, and then added.

The erythrosin or eosin may also be formed into an organic salt of silver, and then added to the emulsion with which the plates are coated. When an emulsion is ready (as described in Chapter XI.) for coating the plate, the following may be added:—A one per cent. solution of erythrosin or eosin in water is prepared, and precipitated with two per cent. of silver. The water is decanted off, and again washed by decantation. This washing is repeated three or four times. Finally, the precipitate is dissolved in a ten per cent. solution of ammonia, only just enough being added to effect solution. To every 100 parts of silver bromide in the emulsion one-tenth part of the erythrosin or eosin precipitate is added, well mixed with it, filtered, and the plates coated. Plates thus prepared are said not to keep any length of time, though we have kept some for eighteen months and found them equal to freshly prepared plates.

In developing these plates, it is well to flood them first with a weak solution of bromide, and follow up with any of the ordinary developers.

Preparation of Wet Plates and Collodion Emulsion Plates.—A wet plate or a collodion emulsion plate may be treated exactly in the same way with good results. With the former, the plate should be washed, and exposed wet. It is then developed with ferrous oxalate developer, after washing well and acidifying the last water but one with acetic acid to neutralise the ammonia present. Where a collodion emulsion has been formed with an excess of silver nitrate the effect will be most marked, probably due to the combination between the slight excess of silver nitrate and the dye.

Colour-Sensitiveness with Cyanin alone.—It is useless to endeavour to prepare bright plates with cyanin alone if they have to be kept long, as they invariably fog. The best plan is to prepare an ordinary plate with it at the time it is required. The plate may be treated as shown above with the cyanin solution, or if cyanin be dissolved in collodion, or in diluted varnish (so that it gives a pale lavender film when poured on a piece of white paper), and be flowed over the surface of an ordinary plate and allowed to dry, it becomes colour-sensitive, more particularly if the maximum admissible quantity of water be added to the solution. When exposed, the plate is flowed over with spirit to soften the film, and, after rinsing with water, is developed. Mr. Ives uses alcohol alone, allowing the flooded plate to dry, and then washes off as much as he can, and exposes whilst damp. The author has found that, for a developer, ferrous oxalate gives the best results in these cases, after the plate has been soaked in a weak solution of potassium bromide for a couple of minutes.

We have found that much iodide in an emulsion is disadvantageous in an orthochromatic plate, and recommend that an emulsion of pure bromide of silver, or bromide and chloride with not more than five per cent. of iodide, be used.

Sensitising to the Red.—When the mixture of malachite green and naphthalene blue are to be used, the following plan may be adopted, according to Vidal. One part of malachite green is dissolved in 200 parts of water heated to 160°, and then mixed with a hot solution of 10 parts of bichromate of potash in 100 parts of water, and heated to 170° for half-an-hour. After filtering, the precipitate is washed well with water and chromised alcohol, and when 6 to 8 parts of sulphate of quinine have been added, 1 part of naphthalene blue is dissolved in 5000 of alcohol. The plates are immersed in malachite green solution 4 parts, blue solution 4 parts, water 600 parts, and kept for two minutes in it.

Mr. G. Higgs, whose beautiful spectrum photography is well known, purifies alizarin blue S for the same purpose. To a saturated solution of sodium bisulphite in a mortar is added the dye in a paste. This is ground up and poured into a glass vessel capable of holding an additional quantity of sodium bisulphite—in all, 10 parts of the paste to 20 parts of bisulphite, and another 10 parts of water. This vessel is well-stoppered, and set aside in a cool place for five or six weeks and shaken daily, but left undisturbed for the last eight or ten days. The solution is then decanted, filtered, and treated with alcohol, which precipitates the greater portion of the remaining sodium bisulphite: 50 parts of water are now added, with sufficient sodium chloride to form a concentrated solution. This is placed in a jar covered with filter-paper for seven or eight days, when a deposition of dye takes place together with calcium sulphite, which latter can be removed by filtration. The alizarin blue S is separated from any unaltered substance left in the original vessel used by solution, and added to the brine, which is purified from brine salts, and is once more set aside to crystallise, the final precipitation being effected by alcohol and a small percentage of water to remove the last traces of sodium chloride. The red, needle-shaped crystals are collected on a filter-paper, and dried at the ordinary temperature. Dilute solutions are yellcw, and with a few drops of ammonia turn finally to blue. Plates are immersed in a 1 : 10,000 solution, with 1 per cent. of ammonia added, and give perfect results the day after preparation, but deteriorate rapidly if not kept quite dry. Cœrulin S may be purified in a similar manner, and used of the same dilution.

Exposing through coloured media.—When the plate has to be exposed through some coloured medium, one plan is to place a glass in front of the lens. Ordinary coloured glass is generally so uneven in surface that it is unsuitable to use, but pieces may be selected. When found, a very suitable method for using is to employ the plan shown in fig. 156. The metal frame holds the glass, and the springs press it in the hood of the lens. Nearly the same effect as the use of an orange glass may be obtained by coating one or two surfaces of the lens with plain collodion stained with turmeric. A saturated solution of turmeric is made in alcohol. Equal parts of this and ether are mixed, and 5 grains to the ounce (one per cent.) of structureless pyroxyline are dissolved in it. The blue in this case is not cut off so decidedly as where the orange glass is employed, but it is sufficient in most cases. Aurine or aurantia may be substituted for the turmeric with good results. A cardboard stop with a thin film of stained gelatine or collodion covering the aperture may also be employed, but it is not always successful, as want of definition is said to be found. Microscopic glass may also be coated with any desired colour by means of gelatine or collodion, and be used in a cardboard stop.

Fig. 156.

CHAPTER XXXV

TRI-CHROMATIC PHOTOGRAPHY FOR PRODUCING COLOURED PICTURES

We have seen in Chapter XXXIV. the method for obtaining pictures in monochrome which render correctly the different colours of nature. Another problem is the production of coloured pictures by means of photography. There are two methods of producing the final picture: the one is by means of projection, in a lantern or its equivalent, and the other by means of printing. Both these methods require for them the production of the same class of negatives, the set taken being available for either method of producing the picture. In order to understand what is required, allusion must be briefly made to the theory of colour vision, which answers in general to all calls made upon it, and which, if it requires alteration in any degree, is in directions which will not interfere with the process we are considering.

Young, who lived at the end of the last century, found that in order to produce any colour only three colours need be mixed. These three colours were red, green, and blue, any other colours (including white) being a mixture of two or the whole of the colours in varying proportions. To put it in more homely language: if three properly chosen coloured rays were mixed and altered in intensity, the mixture would give intermediate colours of the spectrum, and also purples and whites. In other words, any colours of nature would be matched by these three colours. It must be apparent that the colours to be chosen must be selected to correspond, as far as practicable, with the three sensations, and not be taken haphazard. Clerk Maxwell selected three colours which answered very fairly, but except in the case of the green perhaps, they are not quite the best colours that could be chosen. The writer recently has investigated the question, and finds that the colours which most nearly stimulate singly the three sensations are a red near the red lithium line and all colours below it, a green near the E line, and for the third a blue-violet near the blue lithium line of the spectrum. The annexed figure (fig. 157) shows the sensations which are stimulated by the different colours of the spectrum. It appears that, except in the red, the sensations are not excited singly by any part. In the green all three are excited, though the green is that which is most excited, and in the violet we have the blue and the red also stimulated.

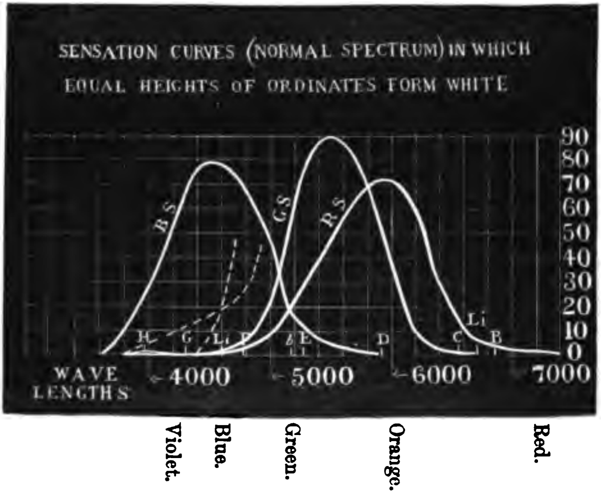

Fig. 157.

The most representative colours for the green and the blue sensations are evidently those with which the sensation is only mixed with white light, and this we find to be at the lines already stated. In the figure it must be said that equal heights of the ordinates of the curves mean equal stimulation of the sensations, and that when all three curves are of equal height, then the combination of the three gives white light. Thus it will be seen that near E the red and violet curves cut one another, and at that point are therefore of equal height, and that there is a surplus quantity of green sensation above that necessary to form white, so that the green sensation is mixed with white.

Now in order to obtain a coloured image by projection of photographs of the spectrum, it will be evident that we must obtain three positives, taking in those parts of the spectrum which are severally occupied by the three sensation curves, and graduated in the same way. These positives, if backed by media which allow only the colours which most nearly match the sensations to pass, will, when their images are superposed on a screen, give the true colours of the spectrum, the limitation being the correctness of the gradation of the photographs and the purity of the colours passing through them. The photographer is interested in obtaining these negatives, and it is to this that we shall in the first instance address ourselves. It will be seen that the positive which has to be backed by the red light should contain all the spectrum, but as at the violet end the light transmitted is small, this region may be neglected, and we come to the conclusion that the range must be from the extreme red to a point just beyond the blue-green. The positive backed by the green medium must extend from the red to the same point, whilst the blue extends from the extreme violet to the orange D line of the spectrum. We have therefore to obtain positives which will nearly coincide in transparency with the curves within these limits, the ultra-violet being cut off to begin with. We have now to make screens for the plates to be used which will give these results. The writer has again utilised the principles involved in the sensitometer described in Chapter XXXIV. The luminosities of the same glasses as were used in making the sensitometer described in that chapter being measured, three glasses were chosen which corresponded closely to the spectrum colours which nearly represent three colour sensations, and a beam of light was passed through each, and allowed to fall upon a screen; and at the same time a beam of light was passed through one of the glasses chosen for the sensitometer, and it was found what mixture of the three colours it was necessary to make in order to match the colour of the latter (as a rule, it will be found that a mixture of two colours will suffice). The same procedure is taken for all the sensitometer glasses. The next operation is to graduate the sensitometer for each negative to be taken. Let us suppose we are dealing

Fig. 158.

Fig. 159.

To face p. 351.

with an orange glass, and it is found that four parts of red light when mixed with three parts of green light are required to form the orange, and that the luminosity of the orange left is 80% of white light falling on it, whilst that of the red is 12%, and that of the green 8%. It is evident that the orange glass must be reduced in luminosity for it to give a negative of equal density with that of the red. But only $\frac{4}{7}$ of the luminosity of the orange is due to the red, that is to say, $\frac{4}{7}$ of 80 or about 46%. We must therefore reduce the luminosity of the orange glass by $\frac{12}{46}$ of 80%, or to close upon 28%. If then a screen be made so that the red with a luminosity of 12% and an orange with a luminosity of 21% will give a negative showing equal densities, it will be correct as far as the colour is concerned.

Taking the negative for the "green" photograph, we find that the luminosity of the colour of the glass is due to $\frac{3}{7}$ of green, that is, 34%. The luminosity of the light transmitted by the green glass is 8% of the white light, the orange glass must therefore be reduced to $\frac{8}{34}$ of 80%, or to about 19%. If then a screen be made so that the green with a luminosity of 8%, and the orange with a luminosity of 19%, give a negative which will show equal densities caused by each of them, it will be correct for these two colours. In the same way we obtain the necessary luminosities for the other glasses, and finally the correct luminosity required is taken, and the luminosities of the others reduced to it, for it does not follow that the three colours chosen to back the positives will be the colour in luminosities of them all, especially when the others are reduced in the way shown. It is not necessary to use all the glasses for each of the three sensitometers, three glasses together with white for each suffices; thus a red, orange, and yellow-green for the red negative, the yellow-green, signal-green, and blue for the green, the violet, blue, and signal-green for the blue negative. Having then made a sensitometer, it remains to use it on the plates selected for the negative. Perhaps the most accurate plate to use is the ordinary gelatine plate, which is sensitive with very prolonged exposure, to the extreme red. The writer found that to reproduce the spectrum colours, if an orange glass were used the negative for the red was rendered well, if a signal-green glass and lemon-yellow were used for the green, the negative for the green was fairly correct, and a cobalt-green and signal-green for the blue negative, that the blue was properly rendered. Fig. 158 shows the three positives from the negatives so obtained.

In the same way the positive of the coloured glasses (white, violet, blue, signal-green, chromium-green, orange, and red) shown in fig. 159 were obtained. The images when backed by appropriate colours when superposed on the screen give the correct colours.

The absorbing glasses used were found by means of the sensitometer described.

If a Cadett spectrum plate or other orthochromatic plate be employed, a new set of colour screens must be formed by the sensitometer in the manner indicated. It is useless to describe the colours in print as they may differ very much in composition. The point to arrive at is that the light passing through each of the colours in each sensitometer should give *very closely* the same density to the plate in development, and the screen placed in front of the lens must be altered till this is attained. These, be it remembered, vary for each brand of plate that may be employed.

When the screens are selected the negatives may be made, and if the positives be properly exposed, so that the highest light is bare glass, the images when superposed after the light has passed through the red, green and blue media appropriate to each, should give the colours of the original very closely. Mr. Ives has constructed a camera which allows all three negatives to be taken with one exposure, and this for field work is almost essential. For the details of construction, reference must be made to Mr. Ives' publication, *The Kromoscope.* For copying pictures and such work this simultaneous exposure is not necessary. It must be remembered that the lens employed should have the same focus for all rays.

Coloured pigments arranged on sectors as in fig. 154 may be employed instead of the sensitometer above described, and will give equally good results. (See *Photographic Journal*, Jan. 1900.) The three negatives having been obtained, it devolves upon the lithographer or photo-engraver to utilise them for colour printing. The colours, if transparent be employed, must be the exact complementaries of the three colour sensations, a fact that is much neglected up to the present.

CHAPTER XXXVI

THEORY OF SILVER PRINTING

SILVER chloride, as has already been said, darkens when exposed to the action of sunlight. It assumes a deep violet tint, and, if it be immersed in water, traces of free chlorine will be found to have been liberated. The light then, by its vibratory energy, decomposes the molecule of silver chloride into a sub-chloride and chlorine (see page 3).*

Silver chloride is soluble in sodium hyposulphite, potassium cyanide, and also in ammonia. When silver chloride has been acted upon by light, and the sub-chloride formed, the hyposulphite or other fixing agent decomposes it, dissolving the silver chloride, leaving metallic silver. Thus—

$$\underset{\text{Silver Sub-chloride}}{Ag_2Cl} = \underset{\text{Chloride of Silver}}{AgCl} + \underset{\text{Silver}}{Ag}$$

When silver nitrate is brought in contact with an organic substance, the resulting compound is found to be affected by light in a somewhat peculiar way: the compound slowly darkens to a reddish tint; the exact chemical reaction that takes place is very complex to trace, but it may be accepted that an oxide of the organic matter and silver is formed. This oxide is stable, unlike the silver oxide, and is not acted on by fixing agents to any great extent.

If a paper be coated with albumen (say) in which has been dissolved a certain quantity of a soluble chloride, and floated

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* It seems probable, however, that the sub-chloride is subsequently oxidised to a certain extent, and that this oxidation is effected not only by what are called the actinic rays, but also by those which are usually inoperative. This, perhaps, may account for the difference that is perceptible between a print which prints slowly, and one in which the action of light is rapid.

on a silver solution, both chloride and albuminate of silver are formed. It depends, however, on the strength of the solution as to what proportion of each is present, owing to the fact that the organic compound is much slower in formation than the chloride, and has less affinity for the silver. If the silver solution be not sufficiently strong, the chloride may rob that portion of it with which it is in contact of all the silver before any (or, at all events, sufficient) albuminate has been formed, the molecule being composed almost entirely of silver chloride. The stronger the silver solution, the more organic salt will it contain; whilst if it be very weak, very little will be present. Hence it is that with albumenised paper which is weakly salted with a soluble chloride, a weak sensitising bath may be used; whilst if it is rich in the chloride, it must be of proportionate strength.

One other chemical reaction in printing must be considered, viz. that of the free silver nitrate which is always present. During printing, as stated, the silver chloride becomes reduced to a sub-chloride, evolving chlorine gas. This chlorine has a stronger affinity for silver than has the nitric acid (with which it is in combination in the silver nitrate), and, consequently, it combines with the silver, forming new silver chloride,* which, in its turn, enters into combination with the organic matter, liberating nitric acid.

This freshly-formed chloride, in its turn, blackens by the action of light, and adds to the strength of the image formed. If the free silver nitrate were absent, we should have the chlorine attacking the darkened chloride of silver already formed,† and partially bleaching it. The result would be "measly" or mealy prints—*i.e.* prints in which minute red spots alternate with darker ones in the shadows after fixing. It will thus be seen that the image of a print is formed by the reduced chloride and also by the organic salt of silver, each playing its part, as will be seen in describing the gelatino-citro-chloride process. The organic salt is sensitive to different radiations to those to which the chloride is sensitive; and much depends on the quality of the light as to which salt of silver is most attacked. In daylight, which is not rich in

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* Probably together with hypochlorous acid.

† Thus, $Ag_2Cl + Cl = 2AgCl$, leaving the organic salt of silver coloured whilst the sub-chloride of the molecule was bleached.

ultra-violet rays, we may expect to find the image formed proportionally more by the organic salt than by the chloride of silver, than if the print be made in electric light, in which they are largely present ; and consequently, after the succeeding operations of toning and fixing, the appearance of the prints in the two cases will be somewhat different.

The most important of the organic substances used in printing is albumen. Hitherto it has been used in preference to any other organic compound, on account of the delicate film it forms, and the beautiful colour the print takes by the production of the albuminate of silver. The albumen should be used fresh, and in a slightly alkaline condition. The principal commercial objection to its employment in such a condition as the foundation of the picture, arises from the difficulty that is experienced in coating the paper evenly with it. When the albumen gives a slightly acid reaction, paper is easily coated, though toning is retarded, and inferior pictures are the result.

Gelatine frequently forms the sizing of paper. The organic silver compound formed with gelatine gives redder tones than the albuminate.

Starch imparts a more purple tint to the picture than the foregoing. Those papers sized with this substance yield the pictures, on toning, of a bluer tint.

Two kinds of paper are principally used for albumenising—Rives and Saxe. They both are starch-sized papers. The latter is much more porous, and consequently less glossy, than the former. Rives paper is, however, tender when wet, and tears easily when used in large pieces, such as required for large prints. Saxe, therefore, is preferred for large prints, whilst Rives is admirably adapted for *small* pictures where great gloss is requisite. Saxe paper can be rendered nearly as glossy as Rives by doubly albumenising and rolling.

Other papers generally give inferior tones to those above specified, though they are constantly employed.

Toning a picture.—If a picture printed on albumenised paper or ordinary salted paper (see pages 358 and 359) were at once immersed in the fixing bath, the resulting colour of the image would be of a disagreeable foxy-red. In order to remedy this, it is usual to tone the picture by means of a solution of gold.

Supposing a print to be thoroughly washed, and immersed in a dilute solution of gold tri-chloride, the following phenomena would present themselves: the picture would gradually bleach, and a blue deposit would take the place of the more vigorous red image, and, on immersion in the fixing bath, the print would be of a most feeble character. The reason of these changes is this: the chlorine from the gold would attack the silver sub-chloride, and, while depositing as a metal, would in reality convert the image back to the state of chloride; owing to one atom of gold combining with three atoms of chlorine, the deposited metal would be much less than if the sub-chloride had been split up into metallic silver and chloride by the fixing bath. Thus—

$$\overset{\text{Silver Sub-chloride}}{3Ag_2Cl} + \overset{\text{Gold Chloride}}{AuCl_3} = \overset{\text{Silver Chloride}}{6AgCl} + \overset{\text{Gold}^{*}}{Au}$$

In the second case we should have—

$$3Ag_2Cl = \overset{\text{Silver Chloride dissolved}}{3AgCl} + \overset{\text{Silver left to form the Print}}{3Ag}$$

In order to avoid loss of vigour, it is usual to add some compound to the gold solution, and in certain cases to leave a small quantity of silver nitrate in the paper. When free silver nitrate is thus present, the compound added to the gold should be a retarder in its action, that when the free nitrate of silver is wholly washed out the compound should be an active absorbent of chlorine.

As an example of the first case, suppose the lime bath be used (see Chapter XXXIX.), where we have a mixture of calcium hypochlorite and calcium chloride; the latter acts as a retarder to the deposit of the gold, as the chlorine from each of these is nearly equally attracted to the silver nitrate. Hence the addition of chloride of lime naturally checks the too rapid deposition of the gold, and the consequent attack on the silver sub-chloride.

As an example of the last case, where all the free nitrate of silver is washed out, sodium acetate has more affinity for chlorine than has the silver sub-chloride; hence there is but slight reduction in the depth of the print in fixing.

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[*] It must not be forgotten that a double chloride is formed when silver nitrate is added to gold tri-chloride. It is probable that an oxide of gold is first formed, and then finally the metallic gold deposited.

It has been assumed that the additions to the toning bath cause the formation of an oxy-chloride of gold. This may be the case, though the argument seems somewhat obscure. A simple experiment with stannous chloride added to the gold solution will give proof that the absorption of chlorine alone is necessary.

The theory of fixing the print has already been given in Chapter IV. Hyposulphite is used, as cyanide attacks the organic oxide formed by light.

CHAPTER XXXVII

PREPARATION OF SENSITIVE PAPERS

Albumenised Paper.—The following is a useful formula for albumenising paper:—

Ammonium chloride	100 to 200 grains	10 *to* 20 *parts*
Spirits of wine	½ ounce	22 ,,
Water	4½ ounces	200 ,,

When these are thoroughly dissolved, fifteen ounces (700 *parts*) of albumen * should be added. These ingredients then should be beaten up with a bundle of quills or a swizzle-stick. Constant shaking for half-an-hour in a bottle (holding about double the quantity of mixture prepared) will answer instead.

Having allowed the deposit in the albumen to settle, it is filtered through a sponge placed in a funnel, and from thence poured into a porcelain or other flat dish. The paper being cut into sheets of convenient size, the opposite corners of a sheet, the smooth side underneath, are taken by the manipulator (one in each hand), and a convex surface is given to it by nearly bringing the two hands together. The middle of the paper first touches the albumen solution, and the corners held by the hand are gradually brought down till the sheet floats on the liquid. The formation of air-bubbles on the surface of the paper is thus prevented, as they are squeezed out. The sheet should remain upon the solution a little over a minute, and then be raised very gradually by one corner, and hung up by two corners † to dry. Should bubbles be inadvertently

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* The eggs used must be nearly fresh. Each good-sized English egg will furnish one ounce, whilst those obtained in the East will only yield five-eighths of an ounce on an average.

† American clips answer for holding the paper whilst drying. The

formed, the paper must be floated again, till a uniform surface is secured.*

When dried, the prepared paper may be rolled, and should be put away flat.

If the paper is floated much longer than stated above, the albumen, being prepared with an alkaline salt, is apt to dissolve the size, and sink into the paper, thus destroying the gloss.

Plain Salted Paper.—Prints on plain paper are useful in certain instances. The formula for preparation is given :—

Ammonium chloride ...	60 to 80 grains...	6 *to* 8 *parts*
Sodium citrate ...	100 „ ...	10 „
Sodium chloride ...	20 to 30 „ ...	2 *to* 3 „
Gelatine	10 „ ...	1 *part*
Distilled water ...	10 ounces	440 *parts*

Or,

Ammonium chloride ...	100 grains...	10 *parts*
Gelatine	10 „ ...	1 *part*
Water	10 ounces...	440 *parts*

The gelatine is first dissolved in hot water, and the remaining components of the formula are added. It is then filtered, and the paper is floated for three minutes, following the directions given on the preceding page. If a print on plain paper be required in a hurry, a wash of citric acid and water (one grain to the ounce) may be brushed over the back of ordinary albumenised paper, and, when dried, that side of the paper may be sensitised and printed in the ordinary manner. For cold tones, the wash of the citric acid may be omitted.

The Sensitising Bath.—A good standard for a sensitising bath is as follows :—

Silver nitrate... ...	... 50 grains ...	1 *part*
Distilled water ...	... 1 ounce ...	9 *parts*

This solution is suitable for most albumenised paper that is to

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temperature of the room or cupboard in which the drying takes place should be kept as high as possible to secure a good gloss.

* For other methods of floating, see Handy-book on *Silver Printing* (Sampson Low, Marston and Co.).

be obtained in the market when it is required to print from good negatives of a fair density. The paper is floated on the sensitising solution from about three minutes in hot weather to five in cold. The method of floating is similar to that given above for floating on the albumen solution.

Care should be also taken to withdraw the paper slowly, as the capillary attraction will then remove nearly all excess of silver solution, and thus prevent a waste by the droppings, and a loss of time in drying. The paper should be hung up from one corner by an American clip, and a small piece of clean blotting-paper should be attached to the bottom corner to collect the excess of solution. This blotting-paper should afterwards be placed with the proper residues.

After a few sheets are sensitised, the solution will be found to be below strength. It can be roughly tested by the argentometer, which is a float showing a specific gravity of the liquid. The greater the depth of immersion, the lower the specific gravity, and consequently the less salts are dissolved in the water. Supposing that silver nitrate alone were dissolved in the water, the number of grains as indicated by the depth of immersion of the float would give the strength of the solution; but as other soluble matters are likely to be found in it after paper has been sensitised, it is evidently an incorrect gauge. The method given in the Appendix is therefore recommended.

The sensitising solution, after a day or two, will be found to become discoloured, owing to albumen being dissolved in it. The method of freeing the solution from organic matter is given at the end of this chapter.

When the sensitised paper is very nearly dry (but not so much as to wrinkle on unrolling it when it is removed from the clip), it should be placed in clean blotting-paper between boards, in order to be flattened for printing.

Should a negative be found very hard, a slight modification of the sensitising solution will be found beneficial, supposing the ordinary paper is to be used:—

Silver nitrate	30 grains ...	1 *part*
Water	1 ounce ...	15 *parts*

The negative should in this case be printed in the sun. The more intense the light, the less contrast there will be in the print, as the strong light more rapidly effects a change in the albuminate than if subjected to weaker diffused light. The reason for the reduction in quantity of the silver nitrate in the solution is given on page 354.

To print from a weak negative, the sensitising solution should be :—

Silver nitrate	80 grains ...	1 *part*
Water	1 ounce ...	5½ *parts*

The printing should take place in the shade; the weaker the negative, the more diffused the light would be.

If a negative be dense, but all the gradations of light and shade be perfect, the strong bath, and, if possible, a strongly-salted paper, should be used. The printing should take place in sunlight.

With a very weak sensitising solution, the albumen may have a tendency to dissolve from off the paper; the addition of ten to twenty grains of sodium nitrate, or a drachm of alcohol, to the ounce of solution, will prevent the evil recurring.

If the baths be new, and no injurious vapours be present in the air, sensitised paper will keep for a couple of days in hot weather, to a week in cold.

Washed Sensitive Paper.—A method of keeping sensitised paper for longer periods (say for a week or a fortnight) without discolouring has been introduced. It is more sensitive, tones more rapidly, and gives more uniform results than the ordinary sensitised paper; the negatives also may be more than ordinarily weak, and still good prints be obtained.

The paper, sensitised as usual, is passed through, *not soaked in*, face downwards, two or three changes of water,* and hung up to dry. The pads of the pressure frame must be fumed with ammonia previous to using the washed paper, in order to produce a rich print—the reason, apparently, being that the alkali combines with the liberated chlorine.† Colonel Stuart Wortley's plan of impregnating the pads with ammonia vapour

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* All the free silver nitrate must not be washed away, otherwise the print will want depth of tone.

† For further information, see Handy-book on *Silver Printing* (Sampson Low, Marston and Co.).

seems the best method of applying it. He places all the pads to be used in a large box over-night, with a little strong ammonia in a saucer; by the morning they are sufficiently impregnated with ammonia vapour.

The sensitising bath should not be acid. If a small quantity of silver carbonate * remain at the bottom of the bottle holding the stock solution, the acidity is prevented. A little powdered chalk added to the bottle answers well.

Colonel Stuart Wortley uses the following bath for sensitising paper that is to be washed :—

Silver nitrate	35 grains	35 *parts*
Lead nitrate	13 ,,	13 ,,
Sugar	2 ,,	2 ,,
Water	1 ounce	440 ,,

The washing paper may be stored between clean and dry blotting-paper, and pressed between two flat boards. The less air admitted to it, the longer it will keep.

Ready Sensitised Papers.—In the market there are two or three ready sensitised papers, which are printed, toned, and fixed in the usual manner. There is sometimes a slight lack of vigour in the resulting prints, however, which is partially overcome by fuming the pads as described above.

Mr. Hopkins adopted a method of preserving ordinarily sensitised paper. He floats the sheets of albumenised paper on a 40-grain bath, as usual; then dries till nearly all the moisture is gone. He then places them between sheets of blotting-paper previously impregnated with sodium-carbonate solution (about thirty grains to the ounce of water), and allowed to desiccate. The pile of paper he places under pressure, and withdraws the sheets as required.

Another plan of keeping paper in a sensitive condition is by adding from twenty to forty grains of citric acid to each ounce of silver nitrate solution. Many find this to give good results, whilst others find a lack of vigour after toning. The writer has found that, if thoroughly washed paper be immersed in a weak solution of potassium nitrite or potassium sulphite, it will also keep well, and that the resulting prints will be as vigorous as unwashed paper, or as with washed but ammonia-

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* The addition of sodium carbonate will form the carbonate of silver.

fumed paper. The fault of the nitrite is its deliquescence. No doubt other salts can be found which are not open to this objection. This opens out future possibilities in printing, as the principle which underlies the process is the application of a chlorine absorbent to the silver chloride.

Mr. W. Bedford prepared sensitive paper that will keep by sensitising on a neutral bath, and then floating the face, whilst still damp, for one minute on a solution of citric acid 30 grains, and silver nitrate 30 grains, to the ounce. Other workers prepare paper to keep by floating the back of the paper on citric acid solution after sensitising.

Resinised Paper.—To the late Mr. Henry Cooper we are indebted for a valuable printing process, founded on substituting resin for albumen, or other sizing matter. The prints obtained by this process are very beautiful, and lack that gloss of albumen which is often called vulgar and inartistic.

The following are the two formulæ which Mr. Cooper communicated to the writer :—

Frankincense	10 grains ...	10 *parts*
Mastic	8 ,, ...	8 ,,
Calcium chloride ...	5 to 10 ,,	5 to 10 ,,
Alcohol	1 ounce ...	440 ,,

When the resins are dissolved in the alcohol, the paper is immersed in the solution, then dried and rolled. The sensitising bath recommended is as follows (though the strong bath given at page 361 will answer) :—

Silver nitrate	60 grains ...	1 *part*
Water	1 ounce ...	7½ *parts*

To the water is added as much gelatine as it will bear without gelatinising at 60° Fah. (15° *C.*).

The second formula gives very beautiful prints, soft and delicate in gradation.

The paper is first coated with an emulsion of white lac in gelatine, which is prepared as follows :—

Three ounces of *fresh* white lac are dissolved in 1 pint of strong alcohol, and after filtering and decanting, as much water is added as it will bear without precipitating the lac ; 1 ounce of good gelatine is soaked and dissolved in the pint of boiling water, and the lac solution is added with frequent stirring. If, at any stage of this operation, the gelatine is precipitated, a little more hot water must be added. The pint of lac solution ought, however, to be emulsified in the gelatine solution.

To use the emulsion, it is warmed, and the paper immersed in or floated on it for three minutes. When dry, the coated surface is floated in the following for a couple of minutes:—

Ammonium chloride	10 grains	1 *part*
*Magnesium lactate	10 „	1 „
Water	1 ounce	44 *parts*

When dry, it is sensitised on a moderately strong bath (that given at page 359 will answer).

If more vigour in the resulting prints be required, it is floated on—

Citric acid	5 grains	1 *part*
White sugar	5 „	1 „
Water	1 ounce	90 *parts*

This last bath improves by use, probably by the accumulation of silver nitrate from the sensitised paper.

The special toning bath for this paper will be found in Chapter XXXIX.

Purifying Printing Baths.—The ordinary method of purifying a printing bath from the albuminate formed is to add a small quantity of pure kaolin, then to shake it up and filter. This method answers perfectly, but is rather wasteful.

If the bath be rendered quite neutral to litmus paper, and be placed in the sun, the organic matter is deposited together with the silver oxide, and the solution rendered pure.

If a small quantity of sodium chloride (common salt) be added, it will be found, on shaking up the silver chloride formed, that the organic matter is deposited with the chloride, and can be separated by filtration. A small quantity of saturated solution of camphor in alcohol will answer the same purpose.

The addition of a sodium carbonate answers equally well, and may be used with advantage. It is generally advisable to have a small quantity of the carbonate of silver at the bottom of the bottle, as by so doing the neutral condition of the bath is ensured, and the organic matter is continually being deposited.

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* Or 10 minims of ammonium lactate.

CHAPTER XXXVIII

PREPARATION OF THE NEGATIVE FOR PRINTING

SKILL is required for obtaining the most perfect prints from any negative, and it is only by paying attention to trifling details that the best results can be obtained. It should be remembered that no blind adherence to any rules will attain the object in view; printing requires thought to be exercised, as well as clean manipulation.

Retouching the Negative.—It would be beyond the scope of this work were the manipulations beyond elementary ones necessary for retouching a portrait or a landscape negative dealt with. We may say that, in retouching a negative, it is necessary that it should be illuminated by diffused light from below, and that the surface should be kept as free as possible from extraneous light. A frame, in which is fitted a piece of glass, held by supports at an angle of 45°, may be placed near a window. The light transmitted through the negative, when placed on the frame, may be reflected from a sheet of cardboard, or from a mirror, if the plate or glass in the frame which supports the negative be ground glass. Should the negative be varnished, the parts which have to be retouched should be prepared to give a "tooth" for the pencil, either by rubbing the varnish where the retouching is to take place with very fine pumice or resin by a very soft pad, or by the finger. Instead of this the varnish may be made matt by using a drop of turpentine in the same manner. The tooth being given, the deep shadows of the face may be lightened by a judicious stippling with an F pencil; or, if still more opacity is required, by a BB pencil. Stippling may be very well imitated by giving the pencil a circular motion, and taking care that no sharp line is made. Cutting the pencil-point to an angle, and using it flat instead of on the point, prevents any danger as regards this. In landscape negatives various small details in the deepest shadows may be strengthened, or even inserted, by a judicious use of the pencil. Should the negative be a gelatine one, it will be found that most surfaces will take the pencil without preparation; if not, they should be varnished. We are not advocates for retouching any negatives, though for portraits some small amount is usually necessary to get rid of defects which are not to be found prominent in the sitter.

Masking the Negative.—Should a picture print too black in the shadows—*i.e.* attain a bronze colour—before the details in the lights have printed in, attention should be given to the rules to be found further on, and further improvement may be effected by shading these dark portions. This shading may be done either by temporarily placing a paper, whilst printing, or by gumming tissue-paper cut to the proper shape on the reverse side of the negative. On the deepest shadows two or more layers of tissue-paper may be gummed, till the desired effect has been attained. In some cases cotton-wool may be placed over a spot which prints too quickly; and in extreme cases, where high-lights are wanted, a skilful touch of the brush (using Indian ink or sepia) on the film side may be given, which gives piquancy to the print which cannot otherwise be obtained.

The prints from landscape negatives frequently show a want of atmosphere in the far and middle distance. In order to give it, the back of the negative should be covered over with tissue-paper,* and the shadows in the distance should be made less obtrusive by means of a stump and powdered crayon. The foreground may be caused to approach by heightening its high-lights. A golden rule to remember is, that the greater the distance of an object, the greyer the high-lights, and less heavy the shadows.

The sky in some negatives prints in too deeply; a mask, cut to the outline of the landscape, and slightly raised from the

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* The paper may simply be gummed round the edges of the negative, or it may be covered with starch and caused to adhere to the whole surface of the back of the plate.

surface of the negative, will give a graduated sky, which, if left too white, may be subsequently improved by "sunning" down. This sunning down is generally carried out by means of a sheet of non-actinic paper or cardboard, which is moved gently over the picture, leaving the upper portion of sky more exposed to the action of the light than the lower portion, the landscape itself being always completely covered up.

In many landscapes some secondary object may attract the eye by the brilliancy of its high-lights. As the object of all artistic photography is to cause the eye primarily to dwell on the most important point, these bright spots, if they interfere with the effect of the picture, should be sunned down by shading all the print except that particular part. This may be secured by making a brown-paper mask, cutting out the shape of the object to be toned down. For this object the negative should be removed, and a clean piece of glass substituted for it in the printing-frame.

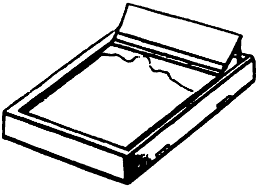

Fig. 160.

Transparent spots in the negative may be touched out on the negative itself. With wet-plate negatives, gum should not be mixed with the paint used (gamboge or lamp-black), as it is apt to cause the film to split. Opaque spots in the negative are always white in the print, and these can only be touched out on the print after it is fixed and dried.

CHAPTER XXXIX

PRINTING, TONING, AND FIXING

In toning operations the print loses depth, varying in a great measure according to the toning bath used, and also to the colour to which they are toned. An allowance in the printing should be made for this loss, the picture when taken out of the frame being darker than what it should be when finished. To determine the proper depth of printing is, perhaps, one of the most difficult things in photography. Practice alone can help the student (see "Maxims" at the end of this chapter).

After the negative has been placed with the film side towards the back of the frame, a piece of paper the size of the plate should be placed on it. A felt or flannel pad should next cover the paper, and the back be placed over this.

The pad is principally used to cause an equal pressure to be exerted between the negative and the paper. Should the pressure be unequal, the paper will not be in contact in places, which will be shown by a fuzzy appearance at those parts of the prints. Even when pads are used, it is not unfrequently the case that this want of contact exists. If the paper has been dried in a moister, hotter, drier, or cooler atmosphere than that in which the printing takes place, the presence of the defect need cause no surprise. It is a good plan to let the paper remain in the printing-room half-an-hour before printing commences, and to place the sheet of paper on the negative in the frame, with the pad behind it, not pressing down the spring on the back. The negative of course should be face downwards on the floor, to prevent the passage of light through it. After five minutes or so, the paper will have contracted or expanded sufficiently to enable complete contact to be maintained.

A great source of defective prints is their examination during printing. The frame should never be opened except in very subdued light, otherwise the whole exposed surface of the print may become discoloured, and the purity of the whites lost.

When prints are removed from the frames, they should be stored in a dark box, or between leaves of clean red blotting-paper in a large book.

Toning the Picture.—The following toning baths are found to give good results. No. 1 is found to be very stable, and to give brilliant results :—

No. 1.—	*Gold tri-chloride ...	2 grains ...	1 *part*
	Chlorinetted lime (chloride of lime) ...	2 " ...	1 "
	Chalk	1 teaspoonful	
	Water	16 ounces ...	3500 *parts*

If the water be hot, the bath may be used when cool ; if not, a day should elapse between mixing and using it.

No. 2.—	Sodium acetate... ...	30 grains ...	30 *parts*
	Gold tri-chloride ...	1 grain ...	1 *part*
	Water	10 ounces ...	4400 *parts*

To be mixed the day before it is used.

No. 3.—	Chloride of lime ...	45 grains ...	1 *part*
	Gold tri-chloride ...	45 " ...	1 "
	Chalk	45 " ...	1 "
	Sodium acetate... ...	180 " ...	4 *parts*
	Water	15 ounces ...	150 "

These to be mixed together, without filtering, from seven to fourteen days before use. When required to use, filter out one ounce of solution, to which add eleven ounces of water.

No. 4.—	Gold tri-chloride ...	1 grain ...	$\frac{1}{10}$ *part*
	Sodium carbonate ...	10 grains ...	1 "
	Water	10 ounces ...	440 *parts*

May be used immediately.

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* It is convenient to make up the gold in proportion of 1 grain to 1 drachm of water, and when a grain is mentioned to measure out 1 drachm of the solution.

No. 5.—Borax	100 grains	10 *parts*
Gold tri-chloride	1 grain	$\frac{1}{10}$ *part*
Water	10 ounces	440 *parts*

These are mixed in equal parts immediately before use. It is well to prepare the borax by means of heat. This bath is excellent for most of the ready-sensitised papers found in the market. Sixteen ounces ($\frac{1}{2}$ *litre*) should tone the whole sheet of paper. Another excellent though old toning bath for the same purpose is the following :—

No. 6.—Sodium phosphate	100 grains	10 *parts*
Gold tri-chloride	1 grain	$\frac{1}{10}$ *part*
Water	10 ounces	440 *parts*

This bath should be made up some hours before it is required for use, and the prints should be well washed before immersion in it.

Other toning baths have been employed, but the foregoing are the principal used with albumenised paper.

Nos. 1, 2, 3, and 6 will keep indefinitely, and they all can be strengthened by adding more gold to them. When the bath becomes inactive from lack of gold, it may be strengthened by a solution containing only one ounce of water to the above quantities of the other ingredients. Nos. 4 and 5 can only be used on the day they are made.

According to the minuteness of the grains of gold, so will it assume, by reflected light, colours varying from a purple to a dirty green. The organo-chloride of silver appears through this layer of gold, and the colours of the two mingling together give the different tones in ordinary prints. When a print is over-toned it becomes blue. This is due to the greater amount of gold deposited over the surface of the silver. The change in colour on the immersion of a print in the fixing bath is due to the solubility of the silver chloride.

With all the toning baths, excepting Nos. 2 and 5, a little of the free silver nitrate should be allowed to remain in the print—that is, before being immersed in the toning bath, the prints should not be too thoroughly washed (see page 356); whilst with the acetate bath it can be shown that all the soluble silver salt should be eliminated. In the first case, the prints should be washed in two changes of water, and the last change should show decided milkiness.* The paper is immersed in the water, with the albumenised face downwards, in order to prevent the silver chloride or carbonate (that may be formed from the soluble chlorides or carbonates in the water) being precipitated on the surface of the print, and the gold being deposited thereon. Should there be a deposit on the print, it is dissolved away by the fixing bath, and leaves minute untoned spots.

The dish for toning should be sufficiently large to contain a couple of prints side by side, but no more should be immersed than can be conveniently turned over without risk; eight or nine medium-sized prints are generally found sufficient. The dish should be given a continuous and gentle rocking motion to cause the solution to flow over and between all the prints immersed, and thus is prevented the adhesion together of any two prints, and the consequent want of tone on those parts which have been in contact. A print must be toned a little deeper than it is intended to remain; for black tones a slight blueness must be perceptible. In all cases, however, *it should possess a rich colour before fixing.*

For resinised paper, Mr. Cooper recommended the following toning bath:—

Solution of gold tri-chloride, 1 grain (1 *part*) to 1 drachm (50 *parts*) of water	2 drachms ...	1 *part*
Pure precipitated chalk ...	a pinch	
Hot water	10 ounces ...	40 *parts*

Two drachms (1 *part*) of sodium acetate are to be placed in the stock-bottle, and the above solution filtered on to it. This is made up to 20 ounces (80 *parts*), and is fit for use in a few hours; but is improved by keeping.

In commencing to tone, place a few ounces of water in the dish, and add an equal quantity of the stock solution, and if the toning begins to flag a little, add more of it from time to time.

With the resin process, over-toning is to be carefully avoided.

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* The milkiness is due to chlorides, or carbonates, or sulphates.

Fixing the Prints.—The usual strength of the fixing bath is—

Sodium hyposulphite	4 ounces[*]	1 *part*
Water	1 pint	5 *parts*

Between toning and fixing it is well to wash the prints slightly, in case there should be any trace of acidity in the liquid adhering to them. After taking them out of the toning bath they should be placed in a dish of water, face downwards, till a batch is ready for fixing.

It will be noticed that the toning action on the print continues during this washing, presumably by the solution of gold contained in the pores of the paper continuing to deposit. The addition of a small quantity of common salt has been found useful to stop this action. If this precaution be not taken, the prints first toned should be redder than it is intended they should remain. The action can also be arrested by acidifying the water. This is dangerous, as the presence of acid in the fixing bath causes a speedy decomposition of the hyposulphite.

The prints should be immersed in the fixing bath for twelve or fifteen minutes,[†] and the solution should be kept in motion during the whole time of fixing, as for toning. Care should be taken to brush off all bubbles that may cling to their surfaces, as the cushion of air impedes the access of the liquid to the silver salt beneath.

When the prints are fixed they will appear colourless in the whites, and free from red patches in the dark portions.

In some establishments it has been found advantageous to add a drachm of ammonia to each pint of fixing solution. The ammonia aids the rapidity of fixing, and neutralises any acid that inadvertently may find its way into the solution; it also attacks the size of the paper, dissolving it out from the paper in some measure. This renders the subsequent washing more thorough, and is found, in most instances, to prevent "blistering," which is common with so many albumenised papers.

The prints should be withdrawn slowly from the bath—in

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[*] One ounce of solid sodium hyposulphite will fix with *safety three sheets of paper.*

[†] The thicker the paper, the longer the time of immersion.

order that all excess of the hyposulphite solution may be drawn from them by capillary attraction—and placed in a trough of water, where they should soak a quarter of an hour. They should then be removed, and placed in a stream of running water for twelve hours. Fig. 161 will give an idea of a very convenient washing-trough, as used by Mr. England. It will be seen that it has a rocking motion to keep the prints in agitation, and that it syphons itself off automatically at intervals.

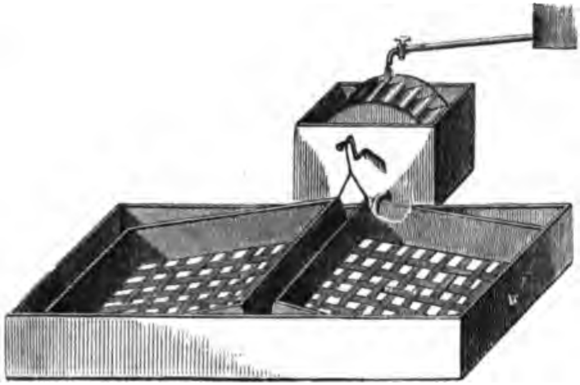

Fig. 161.

Another useful washing apparatus is one by Marion. Fig. 162 will explain its principle.

If running water be not attainable, a good plan is to place the prints in a dish, changing the water every half-hour for five or six changes, and sponging all the moisture out with a thoroughly washed sponge as far as possible after every second change. By this procedure the hyposulphite is very perfectly eliminated. Prints washed in this manner have remained unaltered in colour for the last twenty years in the writer's experience, having passed through climates dry and moist, and varying in temperature from 20° to 110°.

It is sometimes useful to test the water for sodium hyposulphite after the last washing, in order to ascertain if its extraction is complete. Make the following test solution :—

Potassium permanganate ...	2 grains ...	1 *part*
Potassium carbonate ...	20 ,, ...	10 *parts*
Water	1 quart ...	8800 ,,

The addition of a few drops of this rose-coloured solution to a pint of water will yield a slightly pink tinge. If there be any trace of sodium hyposulphite present, the colour will be of a greenish hue.

If the permanganate be not at hand, the following well-known starch-iodide test may be adopted.

Fig. 162.

Take about two drachms of water and a small piece of starch about the size of a small pea, powder, and boil the starch in the water till the solution is quite clear; add one drop of a saturated solution of iodine in alcohol to this clear liquid. It will now become dark blue. Of this solution drop two drops into two clean test-tubes, and fill up one with distilled water, and the other with the water to be tested; a faint blue colour should be perceptible in the first test-tube. In the second test-tube, should hyposulphite be present, this blue colour will have disappeared, the iodide of starch becoming colourless in its presence. The best mode of preparing the two waters is by placing a piece of white paper below the test-tubes, and looking at the paper through the length of the test-tube.

It frequently occurs that though sodium hyposulphite cannot be detected in the washing water, it may be present in the paper itself. The paper on which most prints are taken being sized with starch, if a *very* weak solution of potassium iodide be applied with a brush across the *back* of a print, a blue mark will indicate the *absence* of the hyposulphite, iodide of starch being formed. Care must be taken that the iodide solution is *very* weak, otherwise a part of the iodine will first destroy the trace of the hyposulphite, and then the remainder will bring out the blue re-action.

The dishes used for *toning, sensitising, and fixing should be used for no other purpose* than that to which they are originally allotted. A porcelain dish on which the glaze has cracked should be rejected for the sensitising dish, and for the fixing dish. In the first case, the porous porcelain absorbs a vast quantity of silver nitrate; and in the latter, of old fixing solution, which is *very* apt to cause yellowish markings on the prints.

Tin dishes should be avoided in all cases. The tin corrodes and marks the picture. Perforated zinc is often used for the bottoms of washing troughs. This also should be avoided, as after a time it becomes fouled, the sodium hyposulphite acting upon it, and the prints stain where they touch it.

Alternate Bath for Fixing.—In 1885 the writer found that an excellent fixing bath for silver prints was made by the use of sulphite of soda. The tests so far have proved eminently successful, and give promise of great permanency for the prints fixed with it. Sulphite of soda, like the hyposulphite of soda, decomposes chloride of silver. Sulphite of silver is formed, which is readily soluble in sulphite of soda. This is a stable compound of silver compared with the hyposulphite, its tendency being to form sulphate of silver, and no sulphide. The hyposulphite has eight times the effect of sulphite, hence the cost of the latter is greater—in fact, it is at least twelve times dearer to use; but the writer believes it is worth it on account of the greater chances of stability. The great point is to use enough:—

Sulphite soda	2 ounces ...	1 *part*
Water	10 „ ...	5 *parts*

Two such baths are made up, and placed in two dishes. It is as well to add a little dilute sulphuric acid to the bath until such time as there is a slight smell of sulphurous acid evolved. If the water be warmed, the sulphurous acid will soon be given off. This addition is apparently not necessary, but it is a safeguard. The prints are first placed in the first dish, and after a quarter of an hour are then transferred to the second dish, and left for another ten minutes. They are then taken out and washed in a few changes of water, and the print should be permanent. The *toning should be carried considerably further with* this toning bath than with the hyposulphite. There is no recovery of tone in the bath as there is in the hyposulphite, which shows that no sulphur toning is taking place. As said, 1 ounce of hyposulphite will fix three sheets of paper; not more than half a sheet of paper should be fixed in 1 ounce of sulphite in solution.

Maxims for Printing.

1. The prints should have the highest lights *nearly* white, and the shadows verging on a bronzed colour before toning.
2. Print in the shade, or direct sunshine, according to the density of the negative.
3. Place the prints, before toning, in the water, face downwards, and do not wash away too much of the free nitrate of silver (see exception, page 370).
4. The toning solution must be neutral or slightly alkaline, and not colder than 60°.
5. Tone the prints to purple or sepia, according as warm or brown tints are required.
6. Move the prints, in both the toning and fixing solutions, repeatedly, taking care that no air-bubbles form on the surface.
7. Take care that the fixing bath is not acid.

8. Use fresh sodium hyposulphite solution for each batch of prints to be fixed.

9. Wash thoroughly *before* and *after* fixing.

10. Make a sensitising bath of a strength likely to give the best results with the negatives to be printed; a weak negative should be printed in a feeble light, and a dense negative in sunshine.

CHAPTER XL

DEFECTS IN PRINTS

Defects in Prints.—Small white spots, with a black central pin-point, are often met with in prints. Dust on the paper during sensitising will cause them, the grit forming a nucleus for a minute bubble. All paper should be thoroughly dusted before being floated on the sensitising bath.

Grey, star-like spots arise from small particles of inorganic matter, such as ferric oxide, lime, etc., which are present in the paper. They become more apparent by decomposition during the printing operations. They may generally be discernible by examining the paper by transmitted light.

Bronze lines (straight) occur through a stoppage during floating the paper on the sensitising solution. Should the lines be irregular, forming angles and curves, it is probable that a scum of silver oxide, etc., may be detected on the surface of the sensitising solution. A strip of blotting-paper drawn across the bath will remove the cause of the defect.

Should the print appear marbled, it may be surmised that the sensitising solution is weak, or that the paper has not been floated sufficiently. In some cases it may arise from imperfect albumenising; but in ordinary commercial samples the cause can be easily traced.

Red marks on the shadows may appear during toning, and are very conspicuous after fixing. They generally arise from handling the paper with hot, moist fingers after sensitising; greasy matter being deposited on the surface prevents the toning bath acting properly on such parts.

Weak prints are generally caused by weak negatives. Such can be partially remedied by paying attention to the strength of the sensitising bath (as shown in page 361), and by using washed paper.

Harsh prints are due to harsh negatives. They are generally to be remedied by paying attention to the mode of printing given at page 354. If the negative be under-exposed and wanting in detail there is, however, no cure for this defect. When the high-lights appear too strong, it is not a bad plan to subdue them by sunning the print through the paper.

A red tone is due to insufficient toning; whilst a poor and blue tone is due to an excess of toning.

The whites may appear yellow from imperfect washing, imperfect toning, imperfect fixing, or from the use of old sensitised paper.

Should prints refuse to tone, either the gold has been exhausted, or else a trace of sodium hyposulphite has been carried into the toning bath by the fingers or other means. A trace of hyposulphite is much more injurious to the print than a fair quantity of it. Should the toning bath refuse to tone after the addition of gold, it may be presumed that it is contaminated by a trace of sodium hyposulphite.

A dark mottled appearance in the body of the paper indicates imperfect fixing, combined with the action of the light on the unaltered chloride during fixing. If the fixing bath be acid, the excess of acid combines with the sulphur, and forms hydrosulphuric acid, which will also cause the defect.

The cause of mealiness or "measles" in the print has been explained in Chapter XXXVI.

Blisters are sometimes found during washing, after fixing, beneath the surface of strongly albumenised paper. These arise from a strong saline solution being shut in behind the albumen, which is afterwards in contact with simple water. By putting a little common salt with the first wash-water, this defect may often be avoided.

CHAPTER XLI

COLLODIO AND GELATINO-CITRO-CHLORIDE PAPER

The Collodio-Citro-Chloride Process was introduced by Mr. G. Wharton Simpson. Primarily, it was described for printing on glass or paper, and for such it is given here.

The collodio-chloride is formed as follows :—

No. 1.—Silver nitrate	...	... 1 drachm	... 1 *part*
Distilled water	...	... 1 „	... 1 „
No. 2.—Strontium chloride...	...	... 64 grains	... 1 „
Alcohol	... ...	... 2 ounces	... 14 *parts*
No. 3.—Citric acid ...	...	... 64 grains	... 1 *part*
Alcohol	... ...	... 2 ounces	... 14 *parts*

To every two ounces of plain collodion add thirty drops of No. 1, previously mixed with one drachm of alcohol; then add one drachm of No. 2, shaking well at the same time; lastly, half a drachm of No. 3 solution. In a quarter of an hour it is fit for use. There is sometimes a difficulty found (especially when applying the collodio-chloride to glass), due to the crystallisation of the salts on the surface of the film. The writer has entirely overcome it by using the above proportions, and passing ammonia gas through the emulsion, and so to form citrate of ammonia, and then washing the emulsion thus formed in a similar manner as directed for the bromide emulsion.* It is, however, necessary to add a small quantity of silver nitrate, after re-dissolving the collodion pellicle in the proper proportion of solvents; about 8 grains to the ounce

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* For further details, see *Photography with Emulsions*, Sampson Low, Marston & Co.

of emulsion is the amount recommended. If, however, the paper or plate be immersed in a solution of—

Potassium nitrite	20 grains ...	1 *part*
Water...	1 ounce ...	25 *parts*

the silver may be entirely omitted, and a vigorous image will result. The reason of the addition of the nitrite is the same as that given for adding it to washed paper (see page 359).

The above formulæ apply to printing on paper, or on glass, porcelain, etc.

The paper best adapted for the reception of the collodio-chloride is arrowroot paper, or enamelled paper, such as is used for heliotype or lithography. A paper rather larger than the size of print required is taken, the edges turned up for one-eighth of an inch all round to form a tray, leaving a small spout at one corner. This paper is then placed on a glass plate, and is coated in a dark room with the emulsified collodion, and allowed to dry. It may be found to increase the brilliancy of the resulting print to pin it on the inside of the lid of a large box, and to expose it to the fumes of a drachm of ammonia poured into a saucer, though this is unnecessary when the potassium nitrite is used.

The print is taken in the ordinary manner, and may be toned by any of the ordinary toning baths, the lime bath (No. 1, page 369) being the best, providing it be old.

The following toning bath, made in two separate solutions, gives rather inky tones :—

No. 1.

Ammonium sulpho-cyanate ...	1¼ ounces ...	60 *parts*
Sodium hyposulphite ...	45 grains ...	4·5 „
Sodium carbonate	15 „ ...	1·5 „
Water	50 ounces ...	2200 „

No. 2.

Gold tri-chloride	30 grains ...	3 *parts*
Chalk...	1 teaspoonful	
Water	50 ounces ...	2200 „

Equal quantities of these are taken and mixed, and the toning proceeds as usual. The prints ordinarily take from two to ten minutes to tone. If a longer time be required, add more gold till the desired effect is produced. This toning bath can only be used once.

Gelatine-Citro-Chloride.—The writer introduced a process of printing by means of a citro-chloride in gelatine, which can be applied to paper and glass. His original method of preparation is as follows :—

1.—Sodium chloride	40 grains	4 *parts*
* Potassium citrate	40 „	4 „
Water	1 ounce	44 „
2.—Silver nitrate	150 grains	15 „
Water	1 ounce	44 „
3.—Autotype gelatine	320 grains	32 „
Water	3½ ounces	154 „

Nos. 3 and 2 are mixed together, and then an emulsion formed by adding No. 1 in the usual way when forming a gelatine emulsion. When set, the emulsion is squeezed through canvas into cold water (see page 120), and, after allowing it to remain in the water for ten minutes or a quarter of an hour, dissolved up, with the addition of about 3 drachms (15 *parts*) of alcohol and 2 grains (·2 *part*) of chrome alum dissolved in 2 drachms (10 *parts*) of water. Plates or paper are then coated with the emulsion, and printing takes place in the usual manner. At first the emulsion may appear grainy; if, however, it be boiled for ten minutes, the grain disappears, for the silver citrate is soluble in warm water. The rapidity of printing by the boiling is certainly increased. Plates, when coated, are rather transparent, and, *prima facie*, a vigorous print might not be expected from them. The rapidity of printing is very great; it is more than twice as rapid as ordinary albumenised paper. The image prints of a violet tint by reflected light, and of a rich chocolate colour by transmitted light. If fixed without toning, the colour by transmitted and reflected light is burnt sienna colour, and of great vigour and beauty. Prints can be toned by any of the ordinary toning baths. Borax and chloride of gold (see page

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* The citrate may be reduced to 20 grains (2 *parts*) and the silver nitrate to 120 grains (12 *parts*).

370) gives a pleasant tone; the sulpho-cyanate toning bath (page 381) gives a black, rather approaching an inky tone. Platinum can be used to tone the fixed print, but it has a great reducing action, and there is a tendency for the whites to become yellowed to a slight extent. No doubt endless variations in the organic salts used might be made, but the citrate answers well.

Messrs. Ashman and Offord made the following modification in the above. We think, however, that the gelatine is in too great excess:—

A.—Ammonium chloride	53 grains	53 *parts*	
Gelatine	420 ,,	420 ,,	
Water	20 ounces	8800 ,,	
B.—Silver nitrate	150 grains	150 ,,	
Water	½ ounce	220 ,,	
C.—Sodium citrate	30 grains	30 ,,	
Gelatine	100 ,,	100 ,,	
Water	3½ ounces	1550 ,,	
D.—Silver nitrate	45 grains	45 ,,	
Citric acid	80 ,,	80 ,,	
Water	½ ounce	220 ,,	

The gelatine in A is one-third soft and one-third hard; that in C is all hard. A and B of the solution of each are mixed together, as in making a gelatine emulsion (see Chapter XI.). It is squeezed through canvas and washed as usual, and C and D are emulsified together, and kept at as low a temperature as possible, and then slightly washed. The two emulsions are then mixed together; 15 grains (15 *parts*) of citric acid being added.

The prints should be well washed. It is believed that they would not fade in the same way that albumen prints are so prone to do, as the organic salt used is a definite compound, and not one which is so complex and uncertain as the albuminate of silver is. The liability to fade is less with the above formula than with one which has an excess of silver present. The potassium citrate is in large excess; hence no silver will attack the gelatine.

Mr. Ashman says the following gives a good tone :—

Ammonium sulpho-cyanate	... 1 drachm ...	6 *parts*
Water	... 1 pint ...	880 „
Gold terchloride... ...	... 1 grain ...	$\frac{1}{10}$ *part*

Upon adding the gold, it is converted into a sulpho-cyanate which will be seen to have a red colour. The precipitate, however, dissolves in the excess of sulpho-cyanate, and is then ready for use.

Washing before toning is dependent on the formulæ employed in making the emulsion; in most cases it will be found advisable. Toning action is first seen at the edges, by the colour changing to a yellowish-brown; soon the whole print assumes a sepia tint, then purple, and finally blue-black, the usual time occupied in these changes being less than five minutes. The print should then be transferred to another dish containing a plain solution of ammonic sulpho-cyanate (2 drachms of the salt in 1 pint of water), where it may remain five or ten minutes, after which it should be placed in weak hypo (1 : 10) until the soluble chloride is dissolved. Ammonium sulpho-cyanate alone will be found to fix a plate or paper print made with silver citro-chloride emulsion, but hypo is cheaper and quicker. Should the plates or paper be inclined to frill, place them in saturated chrome alum solution after toning; this in no way affects the colour or purity of the whites. Washing is the same as other gelatine plates and silver prints.

Obernetter's paper is a paper prepared on the above lines, and the toning bath given with his instructions answers admirably for producing almost every shade of print. It is as follows :—

Wash the prints in clean water, and then tone in the following :—

1.—Acetate of soda (re-crystallised)	1 ounce ...	44 *parts*
Chloride of gold	10 grains ...	1 *part*
Distilled water	25 ounces ...	1100 *parts*

2.—In 10 ounces (440 *parts*) distilled water dissolve 2 drachms (12 *parts*) sulpho-cyanide of ammonia, and add 5 grains (½ *part*) of chloride of gold.

Keep each solution separate. To make the toning bath, take 20 ounces of No. 1, and 6 of No. 2; mix, if possible, the evening before using.

The prints must be judged by transmitted light. When toned, they will appear blue in the bath, and brown when looked through. Pass through clear water, and fix.

Prints made on this paper have a tendency to curl when drying. They may be squeegeed on to a flat surface, such as glass or ebonite, the former being slightly greased beforehand. The surface is too glossy to be artistic when plain glass is used, and ground glass may be substituted for it. We ourselves prefer to hang up the prints, and, when nearly dry, press them between sheets of blotting-paper. The inartistic gloss is then not evident.

As regards the light to which these citro-chlorides are sensitive, a reference to fig. 163 will show the advantage they have over the chloride. No. 5 is the spectrum printed on silver chloride; and No. 6 that on the organic compound and chloride. As the ultra-violet rays of the spectrum, which lie beyond H, are deficient in winter, these papers should print quicker than ordinary albumenised paper, since they are sensitive to the green ray.

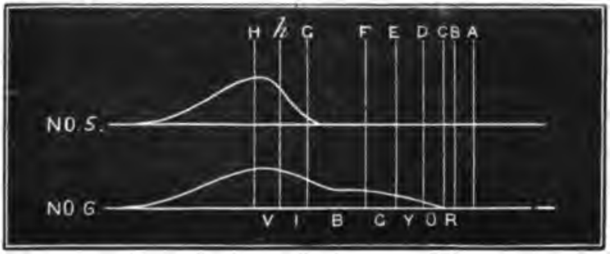

Fig. 163.

The top letters refer to Fraunhofer lines; the bottom letters are the initials of the colours. The height of the curve denotes the relative sensitiveness to the different colours.

Fixing Bath.—The fixing bath for both the above papers is composed as follows:—

Sodium hyposulphite	1 ounce	1 *part*
Water	30 ounces	30 *parts*

The print should be immersed in this for about eight minutes.

The Obernetter and Aristo type papers are now largely superseded by the many gelatino-chloride papers produced by English firms under the names of P. O. P., Solio, Sylvio, etc.

Most of these papers will work well with the toning baths mentioned above, but each maker issues directions and formulæ for use with his paper, and it will generally be found well to adhere to the maker's instructions.

CHAPTER XLII

PRINTING WITH SALTS OF IRON AND URANIUM

THE basis on which these processes are founded is that the ferric and uranic salts are reduced to the ferrous and uranous state by the action of light. Thus, ferric chloride throws off one atom of chlorine, and becomes ferrous chloride.

The most ready process for obtaining prints from a negative by an iron process is that originated by Sir John Herschel, in which the double ferric citrate and ammonium citrate are the sensitive agents. To prepare this salt, precipitate ferrous sulphate (*after thorough boiling with nitric acid*) by ammonia, and wash the oxide by decantation. Next make a saturated solution of citric acid, and add it to the oxide till it is nearly all dissolved ; but note how much citric acid solution has been employed. Take an equal quantity of this same solution, and neutralise it carefully with ammonia, testing with litmus paper, and mix the two solutions.

Dilute this solution to half the bulk, and, after filtering, float plain paper on it. When dried, it may be exposed beneath a negative in the sunlight for two or three minutes, or in good diffused light for a quarter of an hour.

These prints require development, which may be effected by immersing them in a solution of potassium ferricyanide, which will give blue prints. They are fixed by slightly acidulating the first wash-water with hydrochloric acid, and then thoroughly washing in ordinary water.

A silver print may be obtained by floating the print, after exposure, on a dilute solution of silver, which will be partially reduced by the ferrous compound produced by the action of light, and then applying gallic acid and silver (see page 286) to intensify the image. In this case, it is well to fix with sodium hyposulphite, and to wash as usual.

A print may also be formed in metallic gold by brushing over the exposed paper a dilute and neutral solution of gold trichloride.

To fix these last prints, they should be immersed in water slightly acidified with hydrochloric acid, and be then thoroughly washed.

"Blue" Printing Process.—Another plan by which prints can be made direct without development, is based on the fact that if ferricyanide of potassium and a ferric salt be mixed together, and spread on paper and dried, light changes the mixture into an insoluble blue matter, partaking of the nature of Prussian blue. The following solutions answer well:—

Potassium ferricyanide	2½ ounces	2½ *parts*
Water	10 ,,	10 ,,
Ammonio-citrate of iron (ferric salt)	2½ ,,	2½ ,,
Water	10 ,,	10 ,,

The two solutions are dissolved separately, and are then mixed. The solution should be preserved in the dark. To prepare paper, a smooth-surfaced drawing-paper is covered with the mixture by means of a sponge, the strokes of the sponge being crossed so as to obtain as even coating as possible. The surface often looks streaky, but it is not of much consequence as long as the paper is actually covered with the mixture. The paper is not used within three or four days of its preparation. When dry, the paper is used in the ordinary manner, and exposed to light; the printing taking place in five or six minutes, or that necessary for a silver print. A print fully exposed should take a bronzed appearance. The exposed paper is next placed in a dish or tray of water, and a sponge may be used to aid the elimination of the soluble salts from the surface of the paper. When the wash-water is no longer tinged with yellow, the print is sufficiently washed, and has only to be hung up to dry. If drawings or tracings have to be multiplied, they should be exposed with their backs to the sensitive surface, in which case there is no reversal of the image. This process gives *white lines on a blue ground.*

Cyanotypes or Positive Pictures from Positives.—To obtain positive pictures from a positive, a slight modification of the above must be made.

Thirty vols. of gum solution (water 5 parts, gum 1 part) are mixed with 8 vols. of a solution of citrate of iron and ammonia (water 2 parts, double citrate 1 part), and to this is added 5 vols. of a solution of ferric chloride (water 2 parts, ferric chloride 1 part). This is limpid at first, but gradually grows thicker, and should be used soon after mixing. It is applied with a brush to well-sized paper, and dried in the dark. Any design or drawing can be copied by a few minutes' exposure, when it is developed with—

Potassium ferrocyanide ...	50 grains ...	5 *parts*
Water	1 ounce ...	44 ,,

This is applied with a brush, and the picture appears of a dark blue. As soon as every detail has appeared, the print is rapidly rinsed, and put in a dish of hydrochloric acid—

Hydrochloric acid	1 ounce ...	1 *part*
Water	10 ounces ...	10 *parts*

The image becomes clearer, and the background whiter. The details of this process are due to Captain Pizzighelli, of Vienna, and is something like Pellet's process.

According to Dr. Liesegang, Pellet's process (supposed to be a secret) is as follows. The following solution is made:—

Common salt	3 ounces ...	3 *parts*
Ferric chloride	8 ,, ...	8 ,,
Tartaric acid	3¼ ,, ...	3¼ ,,
Water	100 ,, ...	100 ,,

First dissolve 25 ounces (25 *parts*) of powdered gum-arabic in half the water, and dissolve the ingredients in the other half. This mixture is applied with a brush to strongly-sized and well-rolled paper in a subdued light. The coating should be as even as possible. The paper should be dried rapidly to prevent the solution sinking into the pores of the paper. When dry, the paper is ready for exposure. In sunlight, one or two minutes is generally sufficient to impress an image, while in a dull light as much as an hour is necessary. To develop the print, it is floated immediately after leaving the printing frame upon a saturated solution of potassium ferrocyanide; none of the developing solution should be allowed to reach the back. The development is usually complete in less than a minute. The paper may be lifted off the solution when the face is wetted, the development proceeding with that which adheres to the print. A blue colouration to the background shows insufficient exposure, and pale blue over-exposure.

When the development is complete, the print is floated on clear water, and after two or three minutes is placed in acidified water made as follows:—

Sulphuric acid	3 ounces	3 *parts*
Hydrochloric acid	8 "	8 "
Water	100 "	100 "

In about ten minutes' time the acid will have removed all iron salts not turned into the blue compound. It is next thoroughly washed and dried. Blue spots may be removed by a four per cent. solution of caustic potash. These prints show blue lines on a white background, supposing a tracing to have been used as the shield to light. The back of the tracing must be placed in contact with the sensitive surface. This process depends on the fact that ferric salts form a modified Prussian blue when treated with potassium ferrocyanide. The gum in this process, and in that of Pizzighelli, is used to prevent the staining of the background. The best results are often obtained by printing through the paper, in which case the tracing to be copied should be placed with its face to the back.

Uranium Prints.—To print with uranium, the following sensitising bath may be employed, the paper being brushed over or floated:—

Uranic nitrate	80 grains	2 *parts*
Water	1 ounce	11 "

The prints may be developed by the first three developing solutions given for developing the iron prints. With the first one we have a very brown print; with the next the greyish tone, due to the colour of deposited metallic silver; and with the last the purple tone, due to metallic gold.

CHAPTER XLIII

THE PLATINOTYPE PRINTING PROCESS

THIS process was invented and patented by Mr. W. Willis of the Platinotype Company. The method of obtaining prints by this process depends, firstly, on the fact that ferric oxalate is reduced or converted into ferrous oxalate by the action of light; and secondly, that ferrous oxalate, when dissolved in a hot solution of potassic oxalate, instantly reduces the metallic platinum from chlorides and other salts, more particularly when these are in the platinous state.

Now suppose a solution of a platinum salt, such as chloroplatinite of potassium (K_2PtCl_4), be mixed with one of ferric oxalate, and that paper be floated on it and dried, upon exposing such paper to light the ferric salt will be affected, being changed into ferrous salt; and the particles of this ferrous salt will be in contact with the platinum salt. If, now, this insolated paper be floated on a hot solution of potassic oxalate, its ferrous image will be dissolved by the potassic oxalate, but at the moment of solution it will reduce, *in situ*, some or all of the platinum salt so intimately mixed with it, and the result is a picture in pure metallic platinum black. Berkely * states that the following reaction takes place :—

$$\overset{\text{Ferrous Oxalate}}{6Fe(C_2O_4)} \overset{\text{and}}{+} \overset{\text{Chloro-Platinite of Potassium}}{3K_2PtCl_4} \overset{\text{give}}{=} \overset{\text{Ferric Oxalate}}{2Fe_2(C_2O_4)_3} + \overset{\text{Ferric Chloride}}{Fe_2Cl_6} + \overset{\text{Potassium Chloride}}{6KCl} \overset{\text{and Platinum}}{+ \quad 3Pt}$$

Metallic platinum is one of the most stable substances known to chemists, perfectly unalterable by any atmospheric influences, not oxidised in the air at any temperature, and not attacked by any single acid or alkali.

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* *Photographic News*, 1882, p. 157.

Preparing a Paper for Coating.—To prevent too great a penetration of the sensitising solution into the paper, it has to be sized. The choice of the paper itself is somewhat difficult. Ordinary paper will not answer, since it, as a rule, is too tender. Strong paper is to be preferred, and it should be white. Such paper may be obtained from various manufacturers. Its characteristics should be: uniformity, smoothness (where small prints are in question), and purity of colour. A paper that is blue by commercial ultramarine will not answer, as its treatment by hydrochloric acid, which is a necessity in the process of printing, "yellows" it. Any paper must, as we have said above, be sized with gelatine, arrowroot, or algeine. It may be noted that arrowroot and starch give a browner tone to the print than does gelatine, which is favourable for a bluish-black tone. We annex a formula for the sizing solution:—

150 grains of moderately hard gelatine are soaked in 30 ounces of water for half-an-hour, and the water is poured off into a flask or basin, and heated to 140° F. The gelatine is again added to it and dissolved; 45 grains of alum are added, together with 7 ounces of pure methylated spirit. After filtering through muslin, it is placed in a dish somewhat larger than the paper. The solution should occupy a depth of about half-an-inch. The sheets are drawn into this solution, taking care that no air-bells are present, and left for two or three minutes, when they are taken out, and hung up to dry by clips. The drying may be rapid, and the soaking should be repeated, hanging the paper up the second time from the opposite corners. When dry, it is ready to coat. If arrowroot be used, 150 grains of it are rubbed up in a mortar with a little water, and poured gently into 30 ounces of water brought to boiling-point. After the liquid has boiled a short time, methylated spirit is added as above. The alum should not be added. The use of the spirit is to prevent the formation of air-bells.

Preparation of Ferric Oxalate for Platinotype.—For the preparation of this solution of ferric oxalate, the following operations are necessary:—(1) Manufacturing the ferric hydrate; (2) dissolving that substance in oxalic acid; (3) determining the amount of iron and of oxalic acid contained in this solution; (4) diluting and acidulating the same.

The method of preparing ferric hydrate is generally well known, but for the sake of completeness we will give a brief description of it. Ferric chloride, 500 grains, are dissolved in from 12 to 13 ounces of water, and when the solution has been brought to the boiling-point, a solution of soda is added until it gives with litmus paper a distinctly alkaline reaction; for this purpose about 250 grains of caustic soda will be found necessary. The precipitate is then washed with hot water by decantation, until the wash-water is no longer alkaline. It is next placed in a cloth, and by pressure freed from the greater part of the water. With the ferric hydrate thus obtained, which ought to have a syrupy consistency, there should be mixed about 200 grains of finely-crystallised oxalic acid, and the mixture be then left to itself for a few days at a temperature of not more than 30° C., and in a place completely protected from the light. Under these circumstances the formation of ferric oxalate will go on steadily. Some persons recommend the promotion of this process by digesting the mixture for some time at a high temperature; this we are decidedly opposed to, since, by heating for even a few hours to 50° or 60° C., the salt will be partially reduced to ferrous oxalate. At the commencement the solution has a pure green colour; by continued cooking it turns yellowish-green, and finally greenish-brown. When this moment has arrived, the remaining ferric hydrate should be filtered off, and the solution submitted to a quantitative chemical analysis. The amount of iron can be ascertained by evaporating an ounce, heating to redness, incinerating with nitrate of ammonia, and weighing the ferrous oxide which remains.

From the analysis, we ascertain the quantity of ferric oxalate contained in an ounce of the solution, as well as any slight excess of oxalic acid which happens to be present. The liquid is then diluted with so much distilled water that every ounce of it may contain 100 grains of ferric oxalate, $Fe_2(C_2O_4)_3$. Crystallised oxalic acid is then added until, with the free acid already in the mixture, that substance amounts to from six to eight per cent. of the ferric oxalate already in the solution—the normal ferric solution (see page 395, Formula No. 1).

Preparation of Chloro-Platinite of Potassium.—Pizzighelli and Hübl give the following directions:—500 grains of tetrachloride of platinum are dissolved in 2 ounces of water, and the solution filtered, if necessary. This solution is then heated to 100° C. in a water-bath, and a strong stream of washed sulphurous acid, in the gaseous state, is passed through it. After a while, the intensely yellow liquid will begin to turn red, and this is a sign that the platinum chloride has for the greater part been converted into the platinous chloride. From time to time a drop of the liquid is removed by means of a glass rod and tested, to see whether, with a solution of ammonium chloride, it produces the characteristic yellow precipitate of chloro-platinate of ammonium. This test is best performed by bringing together, on a watch-glass, a drop of the solution of sal-ammoniac and one of the solution of platinum. By a comparison of the quantity of precipitate formed, it is easy in this way to regulate the process of reduction; if only a slight formation of the chloro-platinate of ammonium is observed, the stream of gas should be moderate, in order to prevent the reaction from being completed too quickly. So soon as there is no precipitate formed, and none can be produced by rubbing the watch-glass with the glass rod, the flow of gas must be at once interrupted. The conversion of the chloride is now complete, and any further flow of sulphurous acid would be injurious, since a continuation of it means loss of platinum. For, if the action of the gas be continued too long, the platinous chloride is converted into platinous sulphide—a salt which cannot be reduced by an organic ferrous salt. If, on the other hand, the stream of gas is too soon interrupted, the liquid will soon contain some platinic chloride, and this, when the solution of platinum is afterwards mixed with one of potassium chloride, will separate as insoluble chloro-platinate of potassium.

Hence, the reduction of a solution of platinic chloride by means of sulphurous acid gas is an operation requiring the greatest care and attention, particularly towards the end. The solution thus obtained consists of a mixture of platinous chloride, sulphuric acid, and free hydrochloric acid. To convert it into chloro-platinite of potassium, it must be poured, when cold, into a porcelain basin, and a hot solution of 250 grains of chloride of potassium in 1 ounce of water mixed with it, stirring all the while. The chloro-platinite of potassium then separates in the form of a crystalline powder.

After allowing this to cool for twenty-four hours, the crystalline precipitate is collected in a filter, and the mother-liquid is drained off; it is then washed with very little water, and afterwards with alcohol, until the latter has no longer an acid reaction.

The powder is now spread out on filtering paper, and placed to dry in a room to which the light has no access. This precaution seems to be necessary, for the reason that a salt of platinum moistened with alcohol is very liable to become reduced if exposed to the light. The salt prepared in this way is perfectly pure, and in a state to be used for making the sensitising fluid; any further purification by re-crystallisation is therefore quite unnecessary. Provided the above directions are attended to, 740 or 750 grains of the double salt will be obtained from every 1000 grains of platinic chloride, amounting to about 93 per cent. of the quantity which should be obtained on theoretical considerations. No effort need be made to obtain from the mother-liquor a still further proportion of potassium chloro-platinite. The former may be worked up with the other platinum residues.

Coating the Paper.—Capt. Pizzighelli and Baron Hübl, to whom we are indebted for much valuable information on the subject of platinum printing, prepare the following mixtures, according to the class of negative they intend printing from:—

First, a solution of ferric oxalate is prepared—

No. 1.—Ferric oxalate	... ...	120 grains	... 120 *parts*
Water ...	... ...	1 ounce	... 440 ,,
Oxalic acid	... ...	8 grains	... 8 ,,
No. 2.—Of No. 1 ...	... ...	1 ounce	... 440 ,,
Chlorate of potash	...	2 grains	... 2 ,,

Note that great care must be taken that no actinic light gets at either of these solutions, as if it does, the ferric salt is reduced to the ferrous salt. To test whether such is the case, a few drops may be poured on a plate, and a drop of a solution of ferricyanide of potassium mixed with it. If there be a blue colouration produced, the iron has been reduced to the ferrous state, and must be rejected.

The sensitising liquid is prepared as follows :—

I.—Chloro-platinite of potassium solution (80 grs. to 1 oz. of water)	24 dr. fluid	24 *parts*
No. 1	22 ,,	22 ,,
Distilled water	4 ,,	4 ,,

This is a normal solution, and works softly, giving deep blacks.

II.—Chloro-platinite solution	24 drachms	24 *parts*
No. 1	14 ,,	14 ,,
No. 2	8 ,,	8 ,,
Distilled water	4 ,,	4 ,,

This gives brilliant prints.

III.—Chloro-platinate solution	24 drachms	24 *parts*
No. 1	14 ,,	14 ,,
No. 2	8 ,,	8 ,,
Distilled water	4 ,,	4 ,,

This is said to give the gradation of a silver print.

IV.—Chloro-platinite solution	24 drachms	24 *parts*
No. 2	22 ,,	22 ,,
Distilled water	4 ,,	4 ,,

This is a solution to be used for weak negatives.

The effect of adding chlorate of potash is to increase contrasts. It is an oxidising agent, and reduces some small portion of the platinite into a platinic salt. It will thus be seen that, by a judicious use of the chlorate, brilliant prints can be obtained from weak negatives. If chloro-platinite of potassium be obtained commercially, it should be tested in two ways : first, 1 part of the salt should be completely soluble in 6 parts of water ; and second, the solution should not be acid. A solution of the platinite will keep unaltered by light, so may be made up in stock.

The coating must take place in very feeble light. Yellow light is the best, but it is hard to see the colour of the solution. Suppose it be wished to sensitise a surface of paper measuring 8 by 10 or 15 by 12, the simplest method is to place a piece of paper of sufficient size, with its prepared surface uppermost, upon an 8 by 10 or 15 by 12 glass plate, and then to fold the edges of the paper underneath the plate. By placing the plate upon a table (or, better, on a glass plate of larger size), the edges of the paper will be securely held between the plate and the table, and a smooth surface will be secured. The paper must be larger than the plate, to allow its edges to be turned over. Another method of securing a smooth surface is to place the paper on a glass plate of the same dimensions as the paper, and then to clip together the corners of the plate and the paper by means of American clips. Yet another method, which frequently answers well, is to pin the paper by its corners to the smooth surface of a deal board. By the last two methods the corners of the paper are lost, which is not the case with the first method.

The sensitiser is now applied to the surface by means of a pad of cotton-wool, or better, by a pad made by enclosing a tuft of cotton-wool in a small piece of flannel or old gauze under-clothing.

To coat a surface measuring 8 by 10, from 25 to 30 minims of sensitiser will be required. This quantity should be measured, and then poured on the middle of the sheet of paper, and immediately spread over the surface with a circular motion, in as even a manner as possible, by means of the above-described pad. The rubbing should be very gentle, and should be continued until the coating becomes as uniform as possible.

Drying the Paper.—Success much depends on the care with which this operation is performed; the instructions here given should be strictly adhered to.

As soon as the sheet has been coated, it should be hung up by one or both of its corners (on no account should it be laid over a rod) until the surface-moisture has disappeared. Directly this has taken place, the sensitised surface should be dried before a fire or stove, or over a gas-burner. It is of the utmost importance that the paper be *perfectly* dried. The drying point is indicated by the change in colour of the surface, which changes from lemon to orange yellow, and by the crackling sound of the paper. Great care should be taken not to scorch the surface. A scorched sensitive surface gives grey, fogged prints.

It is important to allow a sufficient, but not too long, time to elapse between the coating operation and that of drying. Not less than five nor more than ten minutes should be allowed to elapse between these operations. If paper be dried too soon, too large a portion of the platinum image will wash off in the developer. If not dried quickly enough, the print will be sunken-in and flat.

In very dry weather, particularly in some climates, the surface-moisture will disappear too rapidly—that is, in less than five minutes; in such a case, the atmosphere of the room in which the paper is hung up should be moistened by sprinkling the floor or walls with water, or the paper may be placed in a damping-box or cupboard.

The paper is now ready for exposure under a negative.

When the paper is placed on the negative, it is well to place behind it a sheet of vulcanised india-rubber sheeting or a piece of well-waxed paper, to prevent any damp from the pads affecting the paper during printing. The time of exposure necessary to give to a print depends naturally on the negative; but it is about one-third of that necessary to give to a silver print. The process is most successful with negatives of good density and gradation; though, by careful manipulation in development, almost any negative may be made to yield fair results. Hard negatives require, for instance, a greater heat of solution in development than negatives in which the contrasts, though well marked, are yet not too intense. Weak negatives require a cool solution to obtain the best effects of contrast, but a cool solution never gives the same richness of print which a hot one does. The way to get a really good print from a feeble negative is by using IV. formula, page 396. There is a peculiarity about most ferric salts, which is, that after a reduction by light to the ferrous state a still further reduction is caused by continued exposure, and this is almost equivalent to the reversal of the image in a negative. Thus, if an iron-coated paper be exposed to the spectrum till a faint impression is made on the paper, and is then developed with ferricyanide of potassium or auric chloride, the colours which are absorbed by the iron salt leave their impress, and show varying degrees of intensities. If, however, the exposure be very prolonged, the place of maximum sensitiveness will not develop, but remain white, or be but little coloured, the rest of the spectrum developing properly. If the developing solutions be used hot, this bleaching will not occur nearly so readily. For this reason, then, with a hard negative, where the whites are properly printed the shadows may show slight reversal. To overcome the reversed action a hotter development is advisable. This reversed action can be seen on the print itself; the lemon colour of ferric oxalate first gives place to orange colour, and where this reversed action is suspected the orange tint will be lighter than in the parts less exposed. The exposure may be timed by an actinometer (see Heliotype and Carbon Processes), or can be judged of by examining the print in a very feeble light.

Developing the Print.—Development may take place in a moderately subdued white light. The developing solution is as follows:—

Oxalate of potash (neutral) ...	1300 grains ...	13 *parts*
Water	10 ounces ...	44 ,,

This solution, when made, is conveniently used in an enamelled iron dish supported over some source of heat, such as a Bunsen burner or spirit-lamp, to enable it to be kept at a temperature of between 170° and 180° F. (77° and 82° C.), which is the normal temperature. The depth of fluid in the dish for development should never be less than ¼ inch (5 mm.). The developing solution may be used over and over again, decanting it from any green crystals which may be deposited in the bottle, and adding fresh solutions from time to time. The development takes place by floating the paper on the hot solution in the manner prescribed for albumenising paper; or if the paper be longer than the dish, but narrower, it may be slowly dragged over it by passing it beneath a rod which just touches the surface of the developing solution. In every case the development should be full.

Cleaning and Washing the Print.—The developed print must be passed *from the developing dish into acidified water* (water 60 ounces, hydrochloric acid 1 ounce), and remain face downwards for ten minutes. It should then be passed into another acid bath of a similar strength for the same time, and finally into a third bath, by which time all traces of iron should be removed. That this is effected can be told by the colourlessness of the last acid bath. The prints should be finally washed for a quarter of an hour in two or three changes of water. The

Platinotype Company insist that in no case whatever should the prints be placed in plain water previous to the acidified water. Should a print be over-exposed, it may often be saved by using the developing solution at as low a temperature as 100° F.; whilst with under-exposed prints a temperature above 180° F. may be employed with advantage.

The few following paragraphs are taken from Captain Pizzighelli's and Baron Hübl's work on the process.

After washing, the picture is dried in the ordinary way, and can then, if desired, be mounted. Prints on smooth paper may be hot pressed, to give them a light sheen, which brings up the deep parts.

Prints on linen are treated just the same as those on paper. Linen can be kept stretched on wooden frames after being coated with the sensitiser.

Platinum prints in a wet state appear always more brilliant and lighter than they do when dry. A print, therefore, which, while still wet after development, seems to be quite right as regards tone, would be too dark when dried.

Retouching Platinum Prints.—As the prints have a smooth, horny surface, unlike albumen pictures, they lend themselves admirably to retouching, either with colour or chalk, and may even be painted or drawn upon all over. Their permanence and the absence of any substance in the film which can affect the applied colouring material, protect them from the defect which in silver prints always presents itself after a time—that is, the parts which have been painted or drawn over are observed to vary very disagreeably in colour-tone from the copy. Many sorts permit any kind of retouching; others, again—as, for instance, those which are not properly sized—become disintegrated, and fall to pieces when treated with a hot solution of ferric oxalate and dilute sulphuric acid. Such papers as these should, after being washed, be dipped for several minutes in a saturated solution of alum; they should then be dried, either with or without previous washing.

Defects, and their Cause and Remedy.—Captain Pizzighelli and Baron Hübl give the following list of Defects and Remedies:—

1. *The pictures are vigorous, but more or less fogged.*

a. Cause.—The paper was affected by light, either in sensitising or copying. To prevent it, sensitise only under a weak light, and dry either in complete darkness, or by lamplight. When examining the course of the copying operation, avoid too strong a light in arranging the frame.

b. Cause.—Too high a temperature in drying. It should not exceed 40° C.

c. Cause.—Spoiled ferric solution. The ferric solution is best preserved from the influence of light by being kept in an opaque flask. If you are not confident as to your solution, you must assure yourself, before using it, by testing with red prussiate of potash, that it is free from ferrite. Should it contain only a trace of ferrite, it can be made fit for use again by carefully adding red prussiate of potash. In order to try this, mix a few cubic centimetres of the normal ferric-chlorate solution with every 100 cubic centimetres of the iron solution, and ascertain, by actual experiment on paper, whether the restoration is complete.

d. Cause.—Too long exposure in the printing frame. The time of printing should be shortened, and, if the picture is not yet developed, use a cold developer.

2. *The prints appear weak under the developer.*

a. Cause.—Paper which has become damp. The paper should always be kept in the chloride of calcium box, even after being printed, if not immediately developed. Paper once spoiled cannot be made good again.

b. Cause.—The paper is too old. Paper can generally be kept in good condition for at least six or eight weeks, and sometimes even more; but after that time a gradual change appears to take place, even though it be kept in the dark, and not only weak, but also fogged pictures are the result. As neither time nor trouble are required for sensitising the paper, we recommend only to make at once as much as may be necessary for use during three or four weeks.

c. Cause.—Weak negatives. Use more chlorate of potash in the sensitising solution.

3. *The prints come out vigorous in developing, but become weak after being dried.*

a. Cause.—Paper not sufficiently sized, for which reason the images sink into its substance. When this is the case, employ stronger solutions of gelatine or arrowroot.

b. Cause.—Drying has been too slow. The drying process should not take longer than ten minutes; if this is exceeded, the sensitising solution sinks too deeply into the paper.

4. *The whites of the prints have, after drying, a more or less yellowish tinge.*

a. Cause.—The sensitising solution in the developer is not sufficiently acid. Attention should be paid to the instructions on this point in the previous divisions of the subject.

b. Cause.—Insufficient immersion in hydrochloric acid. The solution of hydrochloric acid must be changed two or three times until the last change no longer turns yellow at the end of ten minutes.

c. Cause.—Paper blued with ultramarine, which when treated with hydrochloric acid turns yellow. Before using the paper, you must be certain that its colour does not suffer from contact with a hot solution of oxalate, and from treatment with hydrochloric acid.

5. *The prints come out hard.*

a. Cause.—Exposure too short.

b. Cause.—Too much chlorate in the sensitising solution. The remedy for this defect is obvious.

6. *Spots and streaks.*

Causes.—Dirty brushes; touching the paper with wet fingers; dirty glass plates; vessels not kept clean, etc.

7. *Black spots.*

a. Cause.—Particles of metal imbedded in the substance of the paper, causing a reduction of the platinum.

b. Cause.—May be due also to insoluble impurities in the chloro-platinite of potassium. These spots have a black nucleus, with an extension, like the tail of a comet, of lighter colour. In such a case, filter the sensitising solution.

Sepia Paper.—The Platinotype Company issue paper which gives tones approaching sepia tones, and for it they give special instructions, which are as follows:—

With few exceptions, the method of carrying out the operations is the same as for the usual kind of platinotype paper. The *additional points* to be attended to are as follows:—When the picture is properly treated, the portions representing the shadows appear more deeply printed than would be the case with the usual kind of paper, because these parts more readily "solarise" (page 398)—indeed, in some cases a large portion of the picture may be so affected. The detail in the delicate portions is not more visible than ordinarily.

Secondly, as the paper is more easily affected by faint rays of light, increased care must be taken when printing. The "sepia" paper does not remain in its best condition for so long a period as the "black" varieties.

To develop, add to each ounce of the solution of potassic oxalate (130 grains in each ounce, or an old bath used for the usual kind of paper may be taken) one drachm of the "Special Solution" supplied for this purpose. Make the bath *thoroughly hot,* and proceed as described in the preceding section. It is important to use a high temperature—not less than 180° Fah.; indeed, the bath cannot be too hot.

A dirty, yellowish veil appearing on development all over the print, but more observable in the lighter portions, is due to one of the following causes:—1. Want of sufficient "Special Solution" in the developer. 2. Too much exposure of the developing solution to light. 3. Use of a dish in which the enamel is cracked so as to expose the iron.

Dishes enamelled *green inside* must not be used: neither should any but porcelain dishes be employed for containing the acid bath.

The bath after use should be put aside in a bottle apart from the ordinary developer, and, like the latter, must not be exposed to much light. This bath, when properly managed, has a tendency to improve with use.

The prints are cleared in an acid bath of 1 part of hydrochloric acid (s. g. 1·16) to 45 parts of water. The subsequent and other operations are the same as for the usual kind of paper.

It is believed that the sepia tones result from use of a salt of mercury with the platinum.

To store the paper for subsequent use, the Platinotype Company supply tin cylinder boxes, round the lid of which slips an india-rubber band in order to exclude the external air with its moisture. Inside, at one end of this cylinder, is fitted a small circular box perforated, in which dry calcium chloride is placed to absorb any accidental moisture which may find its way into the box. A little cotton-wool, or a double thickness of muslin, prevents the access of the calcium chloride to the paper. This compound should be renewed from time to time as it gets damp. The damp chloride may be dried by placing it in an evaporating dish over a Bunsen burner, and heating it strongly—in fact, till it fuses. It may then be broken up and re-used.

It must be recollected that the main success of platinotype depends on maintaining the sensitive paper perfectly dry in all stages until the very moment of development. Hence, the calcium chloride tube should always be reverted to after a paper has been exposed and before development, and it should only be out of the dry atmosphere sufficiently long to allow it being placed on the negative.

Cold Bath Process.—In 1892, Mr. Willis introduced his Cold Bath Platinum Paper. The process immediately became popular, and is now more frequently used than the hot bath process. The image requires to be printed rather deeper on the cold bath paper than on the hot bath variety, and all but the lightest details should be distinctly visible. Development is effected by floating the paper and image downward, upon a 1 in 6 solution of neutral oxalate of potassium, though the strength is not material. A weaker solution will act more slowly and allow of the print being removed if desirable before the image has developed out to full strength. The addition of 1 part of a saturated solution of oxalic acid to 20 parts of the oxalate of potassium solutions will result in colder blacks, while the addition of sufficient carbonate of soda or of potash to turn litmus paper blue will give distinctly warmer tones.

The Platinotype Company recommend the use of their D salts when very cold black tones are desired. The contents of the half-pound packet should be dissolved in 50 ounces of water to form a stock solution. For use, one part of this is diluted with an equal quantity of water. The procedure is the same with all the developers. Sufficient of the solution is poured into a dish to make a bath an inch or more in depth.

The print is taken by opposite corners and laid image downward upon the solution. In a second or two it should be removed and examined for air-bubbles, which must be removed, if present, and the print refloated till development is complete. Or the print, after having been wetted with the developer, may be laid upon a sheet of glass till the desired strength has been attained, when it should be immediately immersed in the clearing bath to check farther action. As the development takes an appreciable time (half a minute or more) to complete, it is well under control, and considerable latitude in the strength of the image is attainable.

Although it is desirable to avoid the formation of air-bubbles and other irregularities in floating the print, they may be rectified by at once wetting the dry parts with the solution and allowing the print to develop to its full strength. In the hot bath development faults of this description cannot be put right; slightly under-exposed prints may be saved by raising the temperature of the bath from the normal condition of 60° to 100° Fah. before the prints are floated. The compensation gained in this way is not very great, and correct exposure should in all cases be aimed at.

Local variations in the strength of the print may be obtained by the adoption of glycerine development.

The print is laid upon a sheet of glass and the whole of the surface painted over with glycerine applied with a flat camel-hair brush. A cup containing a strong solution of developer should be at hand, and one or two other cups containing developer of the same strength diluted with glycerine in varying strengths. A mop-brush of suitable size is dipped in the neat developer, which is painted over the parts of the image required to be of full strength. While these parts are developing the diluted solutions are applied to the other portions of the image, working the various strengths together to avoid harsh and irregular action. Where the image is required to vignette into white paper, the developer should not be brought quite to the limit of the image, but a brush charged with pure glycerine should be worked into the developer on the print, thus diluting it still farther and spreading it out as desired. To work the method successfully, a clear perception of what is required is necessary, together with considerable skill in the use of the brush.

The operations of clearing and washing the prints are the same as for the hot bath paper. The paper, when stored in the air-tight canisters in which it is sold, will keep in perfect condition for many months.

The Platinotype Company prepare paper in the following varieties. The single letter indicates that the paper is for use with the hot bath and the double letter cold bath paper.

A and A A.—A smooth paper suitable for portraiture and other subjects in which all the detail in the negative is to be shown.

C and C C.—A thick rough-surface paper suitable for slightly flatter negatives than the A papers.

S is a smooth paper for sepia tones when developed with a hot solution containing a proportion of Company's "Special Solution."

R S is a rough-surface thick paper for sepia tones under conditions similar to S.

Captain Pizzighelli's Printing-out Process.—Captain Pizzighelli has also introduced a process for direct printing-out. It was described by Gunther in the *Photographic News.* The principles of this method are the following :—

1. If to the sensitising solution certain vehicular substances are added, the solution will be prevented from penetrating into the body of the paper.

2. If to the sensitising solution one of those substances which serve as developers is added in the very beginning, a reduction of the platinum salt takes place directly in the printing frame by atmospheric influences.

The advantages of the new process are, therefore, very important, as there is no longer a necessity for a preliminary preparation of the paper, and as you can judge of the exposure as accurately as with silver. Besides this, the development of the paper is entirely omitted. A simple, short washing of the prints, first in acidulated, then in ordinary water, is sufficient for finishing the pictures.

Sensitising the Paper.—For coating, Rives or Saxe paper may be used, either glossy or with a matt surface.

Solutions of gum-arabic and of arrowroot have been found the best vehicular substances for the sensitising liquid, but the former have proved to give better results than the latter. They are mixed in the following manner :—

1.—Gum-arabic	50 grammes
Distilled water	100 c.c.
2.—Arrowroot	2 grammes
Distilled water	100 c.c.

The latter is boiled in the usual manner to paste. Before use mix—

Sensitising liquid	2 parts
Gum solution 1	1 part

Or—

Sensitising liquid	1 part
Arrowroot paste 2	1 ,,

The mixture is well stirred until it forms an entirely homogeneous liquid, and then it is filtered through muslin.

The coating and drying of the paper, and its storing in tin cylinder boxes in which dry calcium chloride is placed, is the same as in the case of the old platinotype process.

The Sensitising Solution is prepared as follows :—To the normal ferric-oxalate solution is added in the dark-room, and keeping the dish rocking, as much of neutral ammonium or sodium oxalate as will just dissolve at the ordinary temperature. For this purpose will be required of the above-named salts :—

To normal ferric-oxalate solution ...	100 c.c.
Neutral ammonium oxalate ...	18 to 20 grammes
Or to normal ferric-oxalate solution ...	100 c.c.
Neutral sodium oxalate ...	15 to 18 grammes

By formation of the corresponding double salt the brownish-grey colour of the ferric oxalate changes to a beautiful emerald-green. If the solution begins slightly to darken, this will indicate that the saturation is completed. As soon as this takes place, no more ammonium or sodium oxalate should be added ; keep the dish rocking for some further time, allow to set, and then filter.

The solution may be mixed as follows :—

Chloro-platinite of potassium solution (1 part to 6 parts of water)	24 c.c.
Ammonio-ferric oxalate solution, or sodium-ferric oxalate solution ...	22 „
Gum solution 1	23 „

If ammonium oxalate be added, the prints will be of a more bluish tone; whilst, by the addition of sodium oxalate, they are rendered more brownish. The former gives somewhat softer prints than the latter. As to the sensitiveness, there has been found no marked difference between the two salts.

Recovering Platinum from Old Developers.—With proper treatment, we can work with the same developing solution for a considerable time; only when it becomes overloaded with salts of iron to such an extent that crystals separate, or that the colour of the liquid begins to turn dark yellow, it will be advisable to have recourse to a fresh developing solution.

Old solutions of this kind are best used up in the following way. The solution is mixed with about one-fourth its volume of a saturated solution of ferrous sulphate, and heated to boiling-point in a porcelain basin. Platinum then separates in the metallic state, and can be collected on a filter. The filtrate is a solution of ferrous oxalate, and can, in the same way as the old iron developer of the negative process, be converted into potassium oxalate.

The whole of the paper, linen, flannel, etc., containing any salt of platinum or metallic platinum, is collected, and, when a considerable quantity has been brought together, it is incinerated. The ashes remaining after the incineration are stirred up into a thin paste with a mixture of three parts concentrated hydrochloric acid and one part nitric acid; this is then set to digest for a few hours at a temperature of from 50° to 70° C. After this it is diluted with an equal quantity of water, then filtered, and the insoluble remainder washed in the filter with water. From the filtrate and wash-water the platinum is precipitated by adding ammonia, as chloroplatinate of ammonium, and, this being heated to redness, is then converted into metallic platinum.

Any other liquids containing platinum may be mixed with the filtrate obtained by the method described under (2); they can then be worked up together. The metallic platinum obtained by (1) and (2) must be digested in hot hydrochloric acid, to get rid of any remaining trace of iron, and then con-

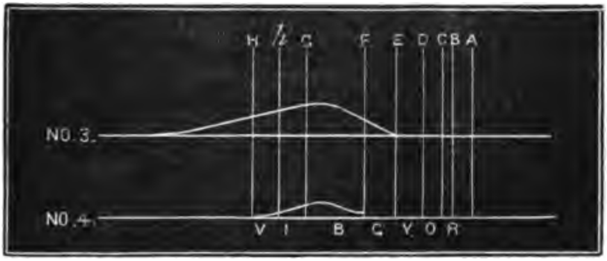

Fig. 164.

The top letters refer to Fraunhofer lines, the bottom letters are the initials of the colours. The height of the curve denotes the relative sensitiveness to the different colours.

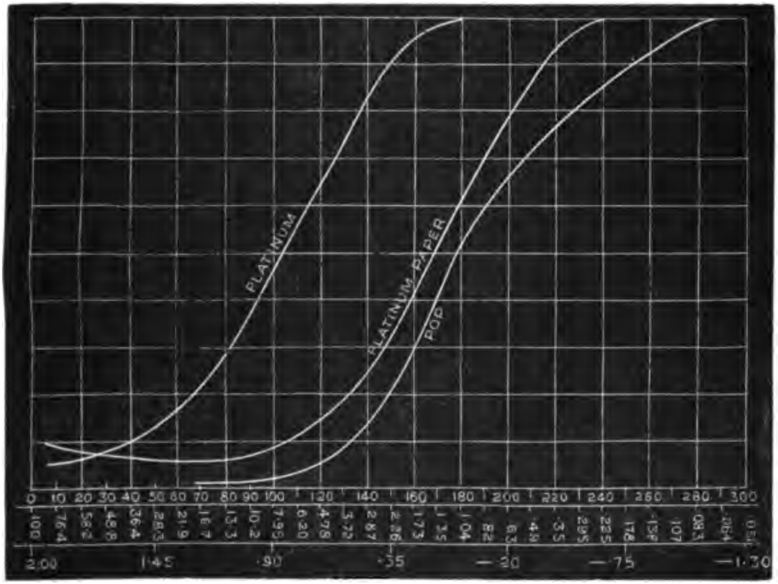

Fig. 165.

verted by the well-known method into platinum-chloride by means of *aqua regia*.

It may be of interest to note the parts of the spectrum (fig. 164) to which the ferric oxalate (and, indeed, most of the iron salts) are sensitive. No. 4 shows a short exposure to the spectrum ; No. 3 shows a longer exposure.

In fig. 165 the gradation of a platinum print with one on silver printing-out paper toned and fixed (P.O.P.) is shown. In the second line at the base are shown the intensities of light that have acted (the top line is degrees of the annulus described at page 139), and the vertical lines of the curve the white light reflected from the print. It will be seen that the P.O.P. paper has a little the advantage of gradation over the platinum print.

CHAPTER XLIV

MOUNTING PRINTS

When prints are taken from the drying-line, they are found to be rolled up, and, it may be, in parts slightly cockled; in this state it is difficult to mount them. The method of stroking prints has been introduced to get rid of the defects. A flat piece of hard wood, about one foot long and one and a half inches broad, and the thickness of a marquoise scale, has its edges carefully rounded off. The print is seized by one corner in one hand and unrolled; the face of the print is brought in contact with a piece of plate-glass. The "stroker," held by the other hand, is brought with its rounded edge on to the back of the print near the corner held by the first hand. Considerable pressure is brought upon the stroker, and the print is drawn through between it and the plate. The print is then seized by another corner, and similarly treated. By this means a gloss is put upon the print, and the creases and cockles are obliterated. The print is now ready for trimming.

It is well to have a square of glass with true edges cut to the size of the picture. The prints should be trimmed upon a sheet of plate-glass, a sharp penknife being used to cut them. A rough test for ascertaining if the opposite sides are equal is to bring them together and see if both corners coincide.

It may sometimes be found useful to cut out a print into an oval. The following method (fig. 166) for tracing any ellipse may be employed. On a thickish piece of clean paper draw a line AB, making it the *extreme* width of the oval required. Bisect it at O, and draw DOC at right angles at AB. Make OC equal to half the smallest diameter of the ellipse. With the centre C and the distance OB draw an arc of a circle, cutting AB in E and F. Place the paper on a flat board, and at E and F fix two drawing-pins. Take a piece of thread and knot it together in such a manner that half its length is equal to AF. Place the thread round the two pins at E and F, and stretch it out to tightness by the point of a lead pencil. Move the pencil guided by the cotton, taking care to keep it upright. The resulting figure will be an ellipse. Modifications of this figure may be made by making a second knot beyond the first knot, and placing the point of the pencil in the loop formed. When the figure has been traced in pencil on paper, it should be carefully cut out with a sharp penknife, and placed on the print which is to be trimmed into an oval. When so placed, a faint pencil line is run round on the print, and the cutting out proceeds either by scissors or penknife. Ovals, in sheet tin or brass of different sizes, are supplied by the dealers in photographic apparatus. The little instrument called the photographic trimmer (fig. 167) is excessively handy for cutting

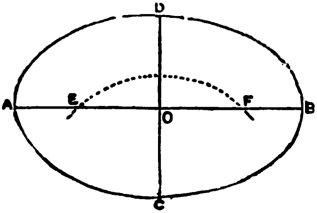

Fig. 166.

Fig. 167.

out the prints when these shapes have been procured. The cutting-wheel is brought against the edge of the shape, and, being pivoted, follows the curves mechanically.

There are a variety of mounting solutions in common use, the most favourite being starch. This is prepared in the ordinary way, and is laid on the back of the print by a hog's bristle brush. Starch is dangerous to use with silver prints unless perfectly *pure* and *fresh;* it is apt to become acid, destroying the print in contact with it. "Stickphast" is very convenient for mounting platinotype prints. It is handy and always ready for use, and has no action on the platinum.

To prepare gelatine for mounting, take half a wine-glassful of gelatine, and cover it with cold water; when thoroughly swelled—which will be in about three-quarters of an hour—pour off any water that has not been absorbed, and fill up the wine-glass with boiling water. The gelatine will now be dissolved, and will remain fluid if the wine-glass be kept standing in warm water. This mounting medium is applied in the same way as the starch. Very thin glue is also occasionally employed, and answers well. In the market, at the present time, there are two or three made-up alcoholic mounting solutions, which answer admirably for small pictures, though when prints of 15 by 12 or over are to be mounted, it is rather difficult to give the back an even coating before the solution dries.

One great advantage of the solutions is that they do not cockle the mount, however thin it may be. Prints may be mounted on foolscap paper with the greatest ease, and they will be as flat as if mounted on the thickest cardboard. A solution suggested by Mr. G. Wharton Simpson is made as follows:—Take gelatine or fine shreds of glue, and swell them with the least possible quantity of water. Boil them with alcohol, keeping them in agitation with a stirring-rod the whole time. Eighty grains of gelatine will take about two ounces of alcohol to render it of a fit consistency for mounting. When cool, the solution will become gelatinous. It can be used for mounting by letting it stand in a pot of warm water.

Before applying the mounting solution, the places where the corners of the print will come on the card should be marked with fine dots. The back of the print, having been brushed over with the mounting solution, should be carefully placed on the mount, the corners coinciding with the dots. A piece of white blotting-paper should next be placed over the print, and the back of the print should be brought in close contact with the mount by rubbing the clenched hand over the blotting-paper. To obtain great evenness, a piece of white cream-laid paper may then be placed over the print, and the edge of an ivory rule or paper-knife be scraped briskly over it. This adds a brilliancy to the print, and prevents cockling in a great measure when starch or gelatine is used, all excess being squeezed out. An excellent plan to adopt to avoid cockling of the print, is to cover the backs with a thin layer of starch, and allow it to dry. Just before mounting, the starch is damped by damp blotting-paper, and it adheres to the mount.

The print is ready for rolling after the mounting solution is well dried, into the details of which it is not necessary to enter. The rolling machine, which takes the form of the ordinary copper-plate press, answers every purpose. Finally, the surface of the mounted print may be waxed. There are various formulæ for the encaustic, the simplest being :—

White wax	1 ounce ...	1 *part*
Spirits of turpentine ...	1 „ ...	1 „

the solution taking plainly by the aid of heat.

Mr. Valentine Blanchard uses white wax dissolved in benzole. This, he states, leaves a good coating of wax on the print, the benzole evaporating entirely.

M. Adam-Salomon's encaustic paste is made as follows :—

Pure virgin wax	500 grains ...	100 *parts*
Gum elemi	10 „ ...	2 „
Benzole	½ ounce ...	44 „
Essence of lavender ...	¾ „	66 „
Oil of spike	1 drachm ...	11 „

The waxing solution may be taken up by a tuft of cotton-wool, and spread roughly over the surface of the print. A clean pad of cotton-wool is then used to rub it well in, till the surface assumes a bright gloss, and is free from all appearance of markings. For increasing the depth of shadow and general beauty of a print, waxing is of the greatest utility.

There are other means of giving what is sometimes called an *inartistic* gloss to the print, the simplest with which we are acquainted being to squeeze a damp print in contact with the surface of a washed and wet plain collodionised glass plate, and to allow them to dry. The print is then stripped off, and the collodion film gives a brilliant surface to the finished print.

Burnishers of a very excellent type have been introduced into the market; figures of two (pages 415, 416) which will answer the purpose are given. Burnishing gives extraordinary brilliancy to a print, and is easily executed with a proper machine.

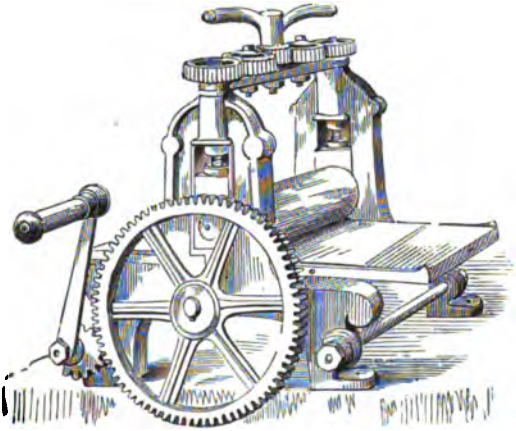

Fig. 168.

Mounting Stereoscopic Prints.—Stereoscopic prints at one time were greatly the fashion, which it is a pity has gone out to a great extent, as views never look so realistic as when viewed in the stereoscope. For the production of a stereoscopic negative, it may be remarked twin lenses of equal focal length are used in the camera, which is generally divided by a movable partition, the lenses being separated one from the other about 2½ inches. The print from such a negative must be cut in half, and the right-hand half mounted on the left hand of a card, and the left-hand half on the right hand. A little reflection will show that this is the position in which the eyes would naturally see them. If mounted as printed we get a pseudoscopic impression on the eyes, which Wheatstone has fully explained.

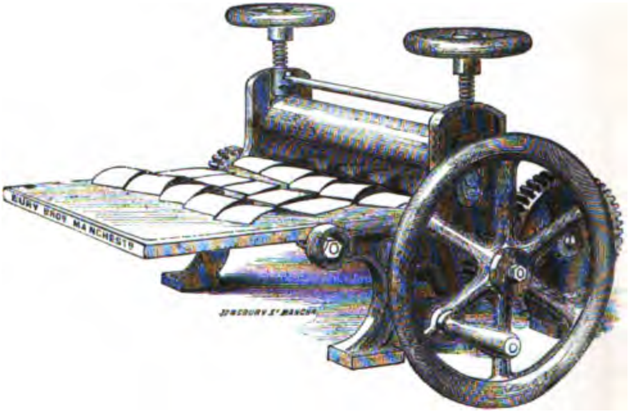

Fig. 169.

CHAPTER XLV

THEORY OF PRINTING WITH DICHROMATES

IF gelatine be mixed with a solution of a dichromate of an alkali, and dried in the dark, it will be found that it is perfectly soluble in warm water. If, however, it be exposed to the action of light, it will be found to have become insoluble. On this rests the whole superstructure of carbon printing, Stannotype, Woodburytype, and some forms of photo-lithography and processes akin to them.

There is another method of producing insolubility in gelatine that does not prevent the absorption of water, viz. the addition to it of chrome alum, tannin, mercurous chloride, and various resins. Not only, however, is insolubility produced by light, but also an inability to swell through the absorption of water, which is not the case when the insolubility is produced by the addition of the above substances. These last, nevertheless, render the gelatine tough, and capable of withstanding a large amount of wear and tear.

Now if a layer of gelatine to which has been added potassium dichromate and (say) chrome alum be exposed to light under a negative, and subsequently immersed in cold water, a little reflection will show that it is *all* insoluble in water; but that where light has acted, it will refuse to swell by the absorption of water; and that where light has not acted, there it will absorb water. If a roller holding greasy ink be passed over such a surface, the ink will be repelled from all the swelled portions, since they contain water, whilst it will adhere only to those parts on which light has acted, and which are free from water. If a piece of paper be pressed down on such an inked-in surface, it is manifest that we shall obtain a positive print on its removal. With half-tone subjects the ink will only take in exact proportion to the time for and intensity with which the light has acted on the gelatine surface, owing to the different parts containing more or less water. On this principle rest the processes of heliotype, papyrotype, and other surface-printing processes. It is also manifest that, if a gelatine film be treated as described in the carbon process, it will form a relief from which a mould may be taken, from which, again, a cast can be taken. This is the principle involved in Stannotype and Woodburytype.

The chemistry of the process is rather involved in difficulties, on account of the organic changes that may take place in the gelatine. It will suffice to point out the main action that takes place, viz. that "gelatine, aided by light, reduces the chromic acid of the bichromate to a lower state of oxidation, and then enters into combination with a compound of chromic oxide produced by the mutual decomposition of the chromic acid and gelatine, being the formation of a leather-like substance" * insoluble in hot water. The addition of various substances to the gelatinous compound has been found to aid this decomposition.

There is one great advantage in the use of bichromate processes over silver chloride, in that they are sensitive to light comparatively low down in the spectrum. The maximum of sensitiveness is in the blue green, whilst that of the chloride is at the extreme limit of the violet. Hence, with it in winter and in dull weather, printing takes place more rapidly than with the ordinary silver sensitised paper. No. 1, fig. 170 (page 419), shows the effect of a prolonged exposure of the spectrum; No. 2 shows a short exposure on same. The remarks on the actinometer used by the Autotype Company (see page 423) show the wonderful difference in the quality of light between summer and winter. It has been found by the writer that when pigment is introduced into the gelatine, the gradation of the print remains the same whatever the pigment may be.

In the figure the intensities of light acting on a carbon tissue are shown at the base, and the amount of white light reflected from the front with each such exposure is shown in the vertical lines, white paper being expressed by 100 and total blackness by 0.

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* From a paper read before the Photographic Society, May 10th, 1870, by Mr. Swan.

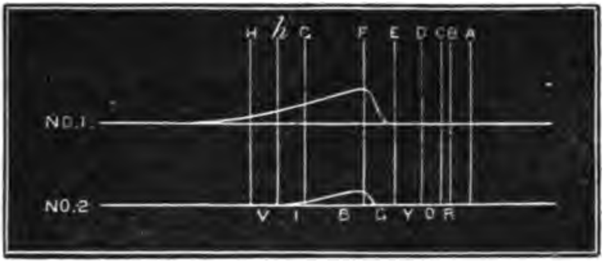

Fig. 170.

The top letters have reference to the Fraunhofer lines, the bottom letters are the initials of the colours. The relative sensitiveness is shown by the height of the curve above the base line.

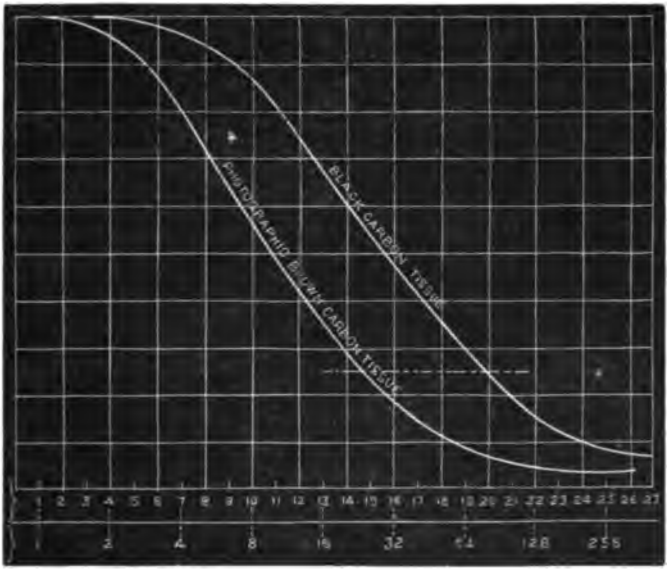

Fig. 171.

CHAPTER XLVI

THE CARBON PROCESS

The Carbon Tissue, as it is termed, is tiresome to prepare on a small scale; hence it is better to procure it direct from some firm. It can be supplied ready-sensitised, and be transmitted by post.

It may happen that the photographer is out of reach of ordinary sources of supply, in which case he may desire to prepare the tissue for himself. The following proportions for the gelatine mixture are taken from Liesegang's *Manual of Carbon Printing*.*

Water	1 ounce	440 *parts*
Gelatine	120 to 150 grains	120 to 150 ,,
Soap	15 ,,	15 ,,
Sugar	21 ,,	21 ,,
Dry colouring matter	4 to 8 ,,	4 to 8 ,,

The gelatine, sugar, and soap should be put into the water and allowed to stand for one hour, and then the colour is carefully ground up and added gradually, the gelatine having been first dissolved by the aid of heat. The mixture is then well stirred up, and finally filtered through muslin (see "Heliotype Process").

The quality of the gelatine is an important matter, and before taking into use it should be roughly tested by soaking 50 grains of it in 1 ounce of water for a few hours. The excess of water, when drained off, should be tested by blue litmus paper for acidity, and for sulphates by the addition of barium chloride. If there be no acidity nor sulphate present,

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* *Manual of Carbon Printing*, by Dr. Liesegang, translated by R. Marston (Sampson Low, Marston, and Co.).

the same amount of water as was drained from it should be added, and the beaker containing it placed in warm water of about 90°. This should dissolve the gelatine, and when cooled it should set and be nearly transparent. If the set gelatine liquefies at a temperature of not less than 80°, it may be used. The best basis of the colouring matter is Indian ink, which can be softened by soaking in rain or distilled water, and then be rubbed down and filtered from the larger particles. The black colour thus obtained can be modified by the addition of alizarin, Vandyke brown, etc.; but there are some colouring matters which render the gelatine insoluble, and are therefore to be avoided.

Manufacturers coat long bands of paper by passing it over the mixture. Since this work is not intended for instruction to those who are commercially engaged in the preparation of tissue, but only for those who are learning photography, we have omitted the description of this method. The following method will be found suitable for preparing a small stock of tissue.

A glass plate is cleaned with nitric acid, next with potash, and finally, whilst still wet with distilled water, rubbed with ox-gall. After carefully levelling (see page 125), sufficient gelatine (about 2½ ounces for a 12 by 10 sheet of paper) is poured on to the plate as in the Heliotype Process. After setting, a sheet of paper slightly damped is laid on the gelatine surface in such a way as to avoid air-bubbles. When the gelatine is dry it adheres to the paper, which is raised, and carries the gelatine with it, the separation of the latter from the glass plate being helped by means of a penknife.

Sensitising the Tissue.—When unsensitised, it is necessary to float it on a solution of potassium dichromate and water:—

Pure potassium dichromate ...	1 ounce ...	1 *part*
Water	20 ounces ...	20 *parts*

The potassium dichromate should be nearly neutral, and contain no free acid. Should it contain acid, the tissue is liable to become insoluble. Free acid* may be neutralised by the addition

* Potassium dichromate always shows a slightly acid reaction to test-paper.

of potash in solution till no extraordinary acid reaction is evident to blue litmus paper. A dish somewhat larger than the sheets of tissue (as the gelatinised paper is called) to be floated is used for floating. The solution should be at least a quarter of an inch in depth in the dish. The piece of pigmented paper is taken, and a quarter of an inch folded back at one end at right angles, and rolled up to a diameter of about two or three inches, gelatine surface outside. The turned-up end remains on the outside of the roll. The angle of the folded end is now dropped upon the solution, and the coil of paper is allowed to unfold itself, driving out all bubbles behind as its surface comes in contact with the solution.

The floating should last from two minutes in warm weather to three in cold.* The turned-up end should then be pinned by a couple of pins on a thin lath, and the sheet of tissue slowly withdrawn from the bath, and hung up to dry.

Drying the Tissue.—The drying of the tissue should take place in a room perfectly free from vapours, such as sulphuretted hydrogen, or those produced by the combustion of gas. If possible, a current of warm, dry air should be created through the drying room; in summer a large candle—or, better still, a gas-jet placed in a chimney—will create sufficient draught, if the paper be dried near the fire-place. The quicker the paper dries, the better it will work, though the less sensitive it is to light.

Exposure of the Print.—When quite dry, the paper is exposed under the negative in the ordinary manner, a "safe edge," as it is technically termed, being placed round it. The safe edge consists of a mask of brown or other non-actinic paper, externally larger than the negative, and internally slightly smaller, the negative being, as it were, framed by it. The pigmented paper must be slightly larger—say a quarter of an inch each way—than the size of the print required. If the paper be examined during exposure, no change will be found in its appearance, owing to the colour of the pigments used; consequently, it is necessary to use an actinometer to time the exposure.

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* Should the temperature of the solution exceed 80° F., it must be reduced by adding a little pounded ice.

The original Autotype actinometer consists of a slip of albumenised paper* rendered sensitive by a standard silver solution. This becomes tinted or coloured by exposure to light. The tint thus produced is compared to a standard one, *painted* on a strip of paper or tin. When about to be used, a small portion of the strip of paper is exposed to the light simultaneously with the print. When the paper has attained the colour of the painted standard, it is said to have had one tint. A fresh piece of paper is then exposed for another tint, and so on.

There is another very simple way of telling the amount of exposure, and that is by the Woodbury photometer. The outer sectors are tinted to different depths with permanent tints. Below the inner circle a piece of sensitised paper is passed, it being coiled on a small roller within the instrument. This sensitised paper is exposed till it assumes, when it is viewed through yellow glass, the tint which is necessary to give to the print, and the tint taken compared with the sectors. The exposure can be timed by a watch, calculating the number of minutes that would be required from the time taken to give a certain tint.

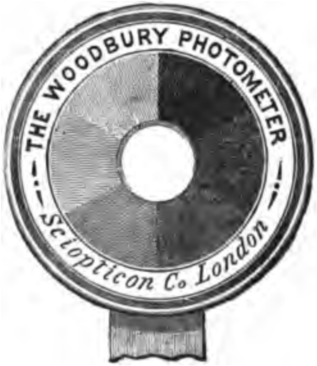

Fig. 172.

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* Other forms of actinometer are employed, which depend more on the principle of that employed for heliotype.

For a negative of ordinary density, two tints of the Autotype actinometer will generally be found sufficient in the summer, and probably five in the winter (see page 418); but experience must decide the time required for different negatives.

The writer believes it would be an improvement to use bromised paper for the actinometer, instead of chloride, since the maximum sensitiveness to the spectrum of the bromide is nearly coincident with that of the bichromate (see page 419). There would not be then that variation in summer and winter which has been noticed above.

Continuating Action.—Some years ago it came to the writer's notice that the length of exposure to light necessary to produce a print by the autotype carbon process might be diminished by three-quarters, or even seven-eighths, by withdrawing the print from beneath the negative, and leaving it in the dark. The printing action once started continued gradually, and on development, after a lapse of several hours, the picture was found to be fully printed. In winter this curious continuating action was of special value, as it enabled from four to eight times the number of prints to be produced from a negative by giving only a quarter to an eighth of the exposure, and then keeping them in a dark room. The writer also experimented with certain non-actinic lights, and found that the same action was maintained, but with greater rapidity. Hence, hanging a partially-exposed print up in a yellow-lighted room was better than leaving it in the dark. When one-quarter of the exposure was given, a print hung up in the dark was found to be properly printed in twelve hours; whilst if only one-eighth, it required sixteen hours. Mr. Foxlee subsequently showed that this action only took place in a moist atmosphere.

Development.—The development of the tissue should be conducted in a room in which the light is weak or non-actinic. Close at hand, on a table, should be a dish containing water to a depth of an inch or more. To the bottom of this is sunk a finely-mulled flat zinc plate, at least one inch larger each way than the negative; the paper is now drawn, face downwards, under the water, till it nearly rests upon the zinc plate. It will be noticed that the paper at first tends to coil downwards, but gradually unrolls till it is perfectly flat, and if left longer that it would coil upwards. At the moment it has become flat, the zinc plate is seized by the hands, and raised horizontally out from the dish, the tissue resting upon it. It is then placed on a small, low stool standing in another dish; one end of the plate is pressed on the zinc plate with one hand, and with the other remaining portions are brought into contact with the "squeegee." * The first portion of the tissue is then brought into contact with the zinc in the same manner.

The zinc plates used are termed the "temporary supports" of the tissue. They are mulled in the ordinary manner with a muller and fine sand: the finer the grain given, the finer in detail will be the resulting pictures. Care should be taken that no scratches are on them, as every scratch is reproduced in the finished print. It was found by the late Mr. J. R. Johnson, who introduced this method of transferring the prints, that it was necessary to coat the plates with a fatty and resinous substance, of sufficient tenacity to keep the prints on them during development, but which should have less adherence to them than the film of gelatine has to the paper with which it is backed or mounted.

The following is the composition of the fatty body :—

Beeswax	3 drachms ...	3 *parts*
Yellow resin† ...	3 " ...	3 "
Oil of turpentine ...	1 pint ...	160 "

These proportions are not absolute, as the composition of the beeswax varies. The resin must be added to the beeswax to such an amount that the gelatine film, even when dried in a hot room, will remain on the plate without cracking or peeling, but, at the same time, will leave the plate readily—when the applied transfer paper has become dried—without the application of any force.

With a piece of fine flannel or cotton-wool, a small quantity of the above fatty body should be rubbed on to the plate.

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* The squeegee consists of a flat piece of wood about two inches wide and three-sixteenths thick, into one edge of which is let a strip of india-rubber about half-an-inch wide, and projecting half that distance; the length of both the lath and india-rubber varies according to the size of the zinc plate. It is used by pressing the india-rubber edge against the paper, and passing it horizontally over the surface.

† The resin causes the adherence of the film to the plate, whilst the beeswax diminishes that adherence to the limits above stated.

With another piece the excess of grease must be polished off, leaving but a minute layer of the compound on the surface. The zinc plate is then ready for the transference to it of the tissue.

The zinc plates are cleaned, after being used, by rubbing with flannel in boiling water. If this be not sufficient, a little turpentine or ammonia will cleanse them thoroughly, and render them fit for a fresh application of the fatty compound.

For some purposes it may be deemed advisable to give the prints a more highly-polished appearance than that furnished by the use of a grained zinc plate. A glass plate prepared as follows answers the purpose:—

Beeswax in shreds ...	60 grains ...	6 *parts*
Methylated ether ...	20 ounces ...	900 ,,

After resting twenty-four hours the solution is decanted. To each part of the clear fluid are then added five parts of benzoline. The plate is coated as with collodion, and dried. A coating of collodion is next given, and the surface thus prepared is used as a temporary support for the tissue.

Development is best effected by a trough or tin basin containing water, whose temperature can be maintained at 100° F. by aid of a gas-jet or a spirit-lamp. After the pigmented paper has been pressed into contact by the squeegee with the zinc plate, it should be laid aside for a couple of minutes to allow the gelatine to swell. By the swelling of the gelatine a partial vacuum is created between it and the zinc plate, and the pressure of the air outside prevents it from peeling or stripping off. The zinc plate, with the adhering paper, is next placed horizontally in the trough for a minute, when it will be found that the paper can be peeled off, leaving the gelatine pigment on the zinc plate. The plate is now moved vertically in the water, or the water dashed over it with the hand; and gradually those parts of the gelatine which have been unacted upon by light will dissolve away, leaving the picture developed, with its half-tones and deep shadows in perfect gradation. When the water flows from off the plate quite free from colouring matter, it should be withdrawn, and then placed for a few seconds in alum and water (a dessert-spoonful to a couple of gallons will suffice). This renders the remaining gelatine less soluble. Should a picture be only slightly under-exposed, plunging the plate into the alum and water at the stage required will stop development and give a passable print. If a picture be slightly over-exposed, water heated to 130° will often reduce its depth sufficiently. The plate, with the picture on it, should lastly be well washed under the tap to rid it of any traces of alum, and then be set up in a rack to dry.

It may seem curious to some that the pigmented gelatine should have to be transferred from paper to zinc plates to be developed, or, in other words, that development takes place from the face not exposed to light. A little thought will clear up the mystery. The light acts upon the pigment according to its intensity and to the *time* of exposure. A ray of light can only penetrate to do work to depth varying with its intensity (the variation is not a simple proportion, but much more complicated), and the amount of "work" done by it is in a ratio to the time of exposure.

The light passing through a negative at different parts varies in intensity. Thus, it is evident that the insoluble part is at the surface, whilst the soluble is nearest the paper. Now, supposing it were attempted to develop the picture on the paper itself, it would be found that *nearly* all the *surface* of the pigment had become insoluble, and that consequently this leather-like substance would prevent the dissolution of the underneath portions, which were still soluble.

The best exposure for the paper is evidently when the light has penetrated in the deepest shadows just to the surface of the paper, whilst the densest parts of the negative have not allowed the passage of *any light*. It will be seen from this that a negative should possess similarly good qualities as if it is to be used for silver printing.

The print on the zinc plate will be found to be reversed. This is as it should be, as in the re-transfer it will be found to be in its proper position. The transfer paper is coated with a preparation of insoluble gelatine. Fifty grains of gelatine (50 *parts*) are dissolved in one ounce (440 *parts*) of water, and three-quarters drachm (41 *parts*) of a saturated solution of chrome alum are added to it immediately before use. A sheet of paper is coated in exactly the same way as that described for making tissue. The re-transfer on to paper is effected in a similar manner to the transfer of the pigmented paper to the zinc. The paper is plunged into water of a temperature of about 170° (77° C.), where it remains till it becomes slimy to the touch. The plate bearing the dried picture is dipped into cold water, and carries as much as possible away with it, and is placed in a horizontal position on to the stool already mentioned. The transfer paper is then placed, prepared side downwards, upon the cushion of water, and is "squeegeed" into close contact with the picture as before. It is then allowed to dry spontaneously (in the sun, if possible), after which it will be found to leave the plate readily, bearing with it the picture on its surface. If dried by the sun it will coil off the plate of its own accord. If the paper be too hastily dried by the fire, it will buckle and become cockled, and can only be flattened with difficulty.

If a matt surface be required, the print may be finished by rubbing with cotton-wool holding a little turpentine. A brilliant surface can be given by using an encaustic paste as for silver prints:—

White wax	1 ounce ...	1 *part*
Benzole	1 „ ...	1 „

dissolved by the aid of heat;

Or—

White wax	1 ounce ...	1 *part*
Oil of turpentine	1 „ ...	1 „

dissolved also by the aid of heat.

For printing portraits a glass plate may be used in lieu of the zinc. As before stated, the surface should be rubbed over with waxing compound. Great care is requisite that the resulting surface is free from lines, as it should be remembered that every line on the surface of the plate will be exactly reproduced in the print. The glass may also be coated with a film of plain collodion (which should be *perfectly* transparent when dry), and, after varnishing round the edges of the film, may be used for the transfer. When re-transferred on to paper the collodion is detached, and the surface of the print is brilliantly glazed. It is advisable sometimes to rub over the plate, before applying the collodion, a little white wax dissolved in ether. This facilitates the film leaving it.

Flexible Support.—Mr. Sawyer, of the Autotype Company, has introduced a flexible temporary support as a substitute for the zinc plate. It is made with a preparation of gelatine, which, with certain substances added to it, cause it to be insoluble and impermeable. The advantage claimed for it is that it expands with the tissue, eliminating the chance of a certain kind of blurring which has often been noticeable in gelatine prints. The results obtained by its employment demonstrate the correctness of the claim. Another point in its favour is, that the surface is less granular than with zinc, and the print is therefore more delicate.

The following is a description of the manufacture of the flexible support, taken from a paper read before the Photographic Society of Great Britain:—

"A solution of gelatine is made of variable strength, according to the quality of the surface desired in the finished print. For a print to have a dead or matt surface, I employ about a 5 per cent. solution; for a more highly-glazed surface, about 7½ per cent.; and for a surface equal to highly-glazed albumenised paper, a 10 per cent. solution. Paper wound on a reel, so as to be in a long length, is coated upon a carbon tissue-making machine with this solution, and, when dry, is cut into strips, and subjected to many tons' pressure in a hydraulic press. The solution of lac is made by dissolving one pound of button or bleached lac in five quarts of water in which have been dissolved four ounces of borax and one ounce of soda. This is put in what is called a digester, and heated until the lac is dissolved. The solution is then filtered, and, when cold, is ready for use. The gelatinised paper is floated on this solution in a shallow bath or tray, hung up to dry, and then finally rolled between metal plates in a rolling press. Each sheet is rubbed over with a little of a solution made by dissolving resin in turpentine, and adding thereto a few grains of wax."

Single Transfer Prints.—There is another method of producing carbon prints without transferring them to zinc, viz. by transferring them direct to the paper on which they should finally rest. In order to employ this method, it is necessary to obtain a reversed negative. The transfer paper, prepared somewhat similarly to the re-transfer paper used in the autotype process, is soaked in very hot water, and, after the carbon tissue has been passed through cold water, the two surfaces are brought together by the squeegee or by pressure. The two papers are then immersed in warm water of about 100° (38° C.), and the backing to the pigmented paper stripped off. The development of the positive takes place as usual, and the paper bearing the print is hung up to dry, when it is ready for mounting and finishing. Single transfer paper may be prepared by soaking white sized paper in water varnish (see "Heliotype Process").

Single transfer gives more delicate results than the double, no grain being present to mar the half-tones. The drawback to the process is the necessity of having a reversed negative.

Abney's Process.—The writer has produced pictures in gelatine in a very simple manner, utilising old celloidin sensitive silver films which are apparently useless, but which can be used up by this plan in a very effective manner. A film which does not contain too much chrome alum to render it totally insoluble, is soaked in a one per cent. solution of bichromate of potash, and allowed to dry. It is then exposed to light, with the *celloidin side next the negative*, till a good visible image is impressed. It is next developed in the usual way, and an image in gelatine and bromide is left behind. This film is next treated with pyrogallic acid and alkali, and the image is silver embeddded in gelatine. The celloidin films are so thin that their thickness does not take away, to any appreciable extent, from the sharpness of the image.

Another Method of Making Reversed Negatives.—Expose a thinly-coated dry plate such as a lantern-plate in contact with the negative (the exposure should be full), and develop the positive image till the deepest shadows are seen strong and black at the back of the plate. Wash the plate and immerse in a 5 per cent. solution of ammonium persulphate till the positive image has been dissolved out, leaving a negative image in bromide of silver. Immerse in a 5 per cent. solution of sulphite of soda to remove the soluble silver salt formed by the persulphate which is left in the film, and wash thoroughly. The image in silver bromide may then be reduced by development to metallic silver, and we have a reversed negative.

Ordinary dry plates may be used for this purpose, but owing to the thickness of the film it will be found difficult to develop the positive image through to the back of the film, and the negative will in consequence be over-dense.

Gum-bichromate and Artigue Processes.—The gum-bichromate process, which is at present much in vogue, was invented by John Pouncey, who received an award for it from the French Photographic Society in 1859. Although the results obtained were quite equal to much of the work done in the present day, the process did not receive general support at the time of its introduction, and was practically forgotten till its revival some five or six years ago.

In 1892, M. Artigue placed upon the market, under the name of "Carbon Velours," a paper coated with a matt surface deposit of pigment held in position by some colloid substance. The paper has to be sensitised by being floated upon a solution of potassium bichromate. It is then dried in the dark, and printed upon from the negative, an actinometer of some sort being required to gauge the exposure.

Development is effected by soaking the paper for some few minutes in cold water, after which it is treated with a mixture of fine sawdust and water. The sawdust mixture, which should be of the consistency of thin batter, is poured from a teapot or similar vessel upon the print supported on a sheet of glass. The abrading action of the sawdust quickly removes the pigment from the portions not acted upon by the light. From time to time the print is laved in cold water in order that the condition of the picture may be inspected. When development is complete the print is immersed in an alum bath for a few minutes, washed and pinned up to dry. Great care must be taken during sensitising, printing, and development to avoid injury to the surface of the prepared paper, as the coating of pigment is very delicate.

The results obtained by the process are comparable for delicacy and gradation to those obtained on platinotype paper.

Soon after the introduction of the Artigue paper, M. R. Demachy and others coated paper in the Pouncey method with gum-arabic, potassium bichromate, and pigment, the prints made upon the paper being developed in a manner similar to the Artigue paper, either with the sawdust and water mixture or with the assistance of a brush.

Many formulæ for preparing the compound of mucilage and pigment have been published. Some workers add the potassium bichromate to the mixture of gum and pigment, others prefer to sensitise the paper with the chromate salt, and, after drying, coat it with the pigment. Others coat the paper with the pigment compound and sensitise afterwards.

The following abbreviation from a paper read by Mr. James Packham will give the necessary information to those who desire to experiment with the process:—

These papers have been found serviceable. Michallet, a heavy paper, coarse in texture, with ribs upon it, crossing at right angles. It readily absorbs the bichromate solution, and takes a thin and even coating of the pigmented gum.

Allongé, with a fine and even grain, is well suited for the process.

Lallane, a much lighter paper, something like Michallet, but with more delicate markings.

English cartridge paper has on one side a surface similar to Allongé, but as it is heavily sized, the prints upon it have a tendency to hardness, although clear high-lights are easily obtainable.

Whatman's papers give excellent results, and the coarser papers are suited for very broad effects.

Most papers that absorb the bichromate solution and dry to a deep orange tint may be relied upon to work efficiently, if they do not allow the pigmented gum to become too intimately associated with the fibre.

Sensitising the Paper.—The paper should be saturated with a 10 per cent. solution of potassium bichromate. A pencil-mark should be made upon the reverse side of the paper to that selected to bear the image. Pour into a deep developing dish sufficient bichromate solution to cover all the paper that is to be sensitised. The paper will be found to absorb the bichromate more evenly if the solution is kept at a temperature between 60° and 70° Fah. Take each sheet of paper separately and immerse in the solution, and remove air-bells from both sides. When all have been immersed, bring each sheet in turn from the bottom to the top and examine for air-bells; when this has been done and the paper is completely and evenly saturated, remove each sheet separately, drain and pin up to dry with a piece of bibulous paper attached to the lower corner by its own adhesion to absorb superfluous solution. The paper must be dried and stored in darkness or in non-actinic light.

Paper, if not heavily sized when prepared and stored in this way, will keep in good condition for a considerable time. The deterioration of prepared paper is recognised by the change of colour from a bright yellow or orange to a dirty greenish-brown.

The Gum Mucilage and Pigment.—The only gum which can be used with certainty is the Soudan gum acacia, known as Turkey, and should be bought in tears, not in powder.

For a stock solution dissolve four parts of gum in ten parts of cold water. If broken in small pieces and occasionally stirred, it will dissolve in one evening. Strain out the woody impurities through muslin and allow others to subside in the bottle, which should be kept well corked.

To prepare the mixture of pigment, none but dry colours should be used, as the results with tube colours are uncertain, the nature of the medium not being known, and the proportion of pigment difficult to estimate when a paste or cake-colour is used. A useful selection of powder pigments is vegetable black, red, and yellow ochre, burnt sienna and burnt umber.

It is advisable to work with weighed and measured quantities, and to book the formulæ. To mix the gum and pigment, take half a fluid ounce of the 4 in 10 solution of gum, and add half-an-ounce of water, and thoroughly mix. Place 12 grains of vegetable black upon a sheet of ground glass or marble slab, add a few drops of the mucilage, incorporate and grind together with a palette knife for five or ten minutes. The beauty of the print depends upon this being well done. Take up the mixture with the palette knife and transfer to a cup; pour some more of the mucilage upon the slab to work up, and remove the remaining pigment which is also to be transferred to the cup; add to this the remainder of the mucilage and work together with a brush.

To Coat the Paper.—The brush most convenient for the purpose is a 2-inch bear's-hair set in tin. Place upon a drawing-board two thicknesses of blotting-paper, and upon this press down a sheet of the bichromated paper, which should be "bone dry." Fill the brush with the thoroughly mixed pigment and mucilage, scraping out the redundant colour on the edge of the cup. Spread the colour evenly over the paper, crossing it with the brush once or twice.

As the paper expands take out the drawing-pins, stretch it out flat and pin down again. Now take a 4-inch badger's-hair brush known as a "softener," hold it vertically over the paper by two fingers and the thumb about an inch and a half from the top of the handle, and pass it over the surface of the paper till the coating is nearly dry, and until it is evenly coated with a thin semi-transparent coating of the pigmented gum. The peculiar action in using the brush is not easy to describe; the pressure should neither be very gentle nor very heavy, the motion is a sort of rapid hop, skip, and jump action only to be acquired by practice, but very effectual in obtaining absolute uniformity of coating.

Failure will result from the use of too much pigment; excellent results can be obtained with 7 grains of vegetable black to once ounce of the diluted mucilage, and double that quantity is sufficient for pictures with the deepest shadows. To test if the paper has been correctly coated, cut off a small piece, dry it, and float it, face side downward, upon cold water. The pigmented mucilage should all drop from the surface, or if not quite clean, should become so with a very slight laving with water, or with the slightest touch of a camel's-hair brush.

The paper after coating is best dried spontaneously; but if it is intended to be kept for a few days, it must be thoroughly dried by a gentle heat before being placed in the portfolio.

Exposure and Development.—The printing should be done in bright diffused light, but not sunlight. As a rule, two or three gradations of a Burton's actinometer will be found sufficient upon not too heavily coated paper, employing the black or yellow side of a strip of the actual paper in use as an indicating medium.

Red and brown pigments require a longer exposure than black. The exposure may be considered complete when the principal shadows are fairly evident by transmitted light.

Over-exposure gives softness, and if carried too far obscures the half-tones and high-lights. With under-exposure the semi-tints are completely soluble.

To effect development, place the exposed print face downward upon a deep dish of cold water, and allow it to float in this manner for five or ten minutes; raise one corner gently, and some idea of the treatment required will be obtained. If the pigment in the high-lights and half-tones has begun to move, the treatment must be very gentle. If the pigment has begun to move from the unexposed margins and not from the body of the print, a full exposure has probably been made. In the latter case allow the print to float for another ten minutes or more, occasionally changing the water to wash out the bichromate stain. Do not allow the face of the print to remain face upward, unless it be frequently rinsed, or stains will result.

Remove the print from the water, and lay it face upward upon a thin board, to which it should be clipped at one end. If under-exposed, very gentle laving with water will remove all the soluble colour, but if some parts resist the gentle action of the water, take a large-sized camel's-hair mop and gently touch those places, beginning with the margins and foreground, occasionally flowing from the top end a plentiful supply of cold water to wash away the dissolved pigment. Some of the shadows may still be clogged; work upon them by gently stabbing with the mop-brush, which should be well charged with water.

After development it is necessary to pass the print through a bleaching bath to remove the bichromate stain. The bath may be alum, sodium sulphite, or sodium hyposulphite; strength is not very material, but if the prints have been weakly printed the bath must be weak. The prints must be well washed for a few minutes afterwards, and allowed to dry spontaneously.

If Mr. Packham's instructions are closely followed, satisfactory results will be obtained.*

The Ozotype process.—This process is the invention of Mr. T. Manly, who demonstrated the working of it before the

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* Mr. Packham's paper will be found in the *B. J. Almanack* for 1899, pp. 806—810.

Royal Photographic Society, on March 28th, 1899. A sheet of paper, coated with gelatine, is brushed over with a solution containing chromate or bichromate salts, manganous sulphate, manganous chloride, aluminium sulphate, and boric acid. The paper is dried in the dark, and will keep indefinitely. It is printed upon from a negative in the ordinary way, and is developed by washing out the unexposed salts with cold water, leaving the image in brown upon a white ground. This forms the substratum upon which a stronger image in pigmented gelatine may be developed. The print is dried, and in that state will keep indefinitely. To complete the print a sheet of carbon tissue is soaked for one minute in a bath of

Water	1000 c.c.
Glacial acetic acid	2 to 5 ,,
Hydrokinone	½ ,, 2 grammes

or in the solution mentioned in the patent specification. Other developing agents, such as pyrogallic acid and the phenol derivatives, may be used in place of the hydrokinone.

The bath may be modified to suit the nature of the negative, and the exposure which the print has received. Slight increase in the proportions of acetic acid will give contrast, and increasing the proportion of hydrokinone will give soft effects. The temperature of the bath should not be less than 65°, and not higher than 75° Fah. In this the insensitive carbon tissue is placed for one minute with the print. They are drawn out together and squeegeed into contact, and hung up to dry. When dry the print and adherent tissue are soaked in water for not more than half-an-hour.

It is then developed in water at a temperature of about 102° Fah. in the manner usual with carbon tissue, and finished and dried in the ordinary way.

In this process no actinometer is necessary, as the image can be seen during printing, and the image is not reversed as in the case of single transfer carbon printing. Any of the ordinary tissues may be used in this process, but a tissue coated with a thin layer of gelatine heavily pigmented is desirable to avoid the spreading of the image which takes place with a thick coating of gelatine.

The original print may be made upon any kind of paper, which should be coated with a thin layer of gelatine. It is not necessary that the gelatine should be rendered insoluble, as the action of the light, followed by immersion in the acid and hydrokinone bath, will effect this. Papers coated with insoluble gelatine such as single transfer paper may be used.

Mr. Manly also suggests that the print may be coated with pigmented gelatine or pigmented gum and developed (after soaking in the acid and hydrokinone solutions) as in the gum bichromate process.

The following description of the process is given by Mr. Manly in his patent specification:—

I coat in any convenient way paper, or other suitable material, with an aqueous solution (which I shall hereafter refer to as the sensitising solution) containing the following ingredients, namely, the bichromate salts, or chromic acid, or other similar light-sensitive compounds of chromium, manganous sulphate, or manganous chloride, or other manganous salts, and a preservative, such as boric acid and aluminium sulphate or alum, mixed together in suitable proportions.

In place of the above-mentioned salts of manganese, the cupric, cobaltous, and nickel salts, and other metallic salts capable of giving oxides on exposure to light in presence of the light-sensitive compounds of chromium may be used. After the paper and other material thus prepared and rendered sensitive to light has been dried, it is exposed to light under a negative or other screen, producing a brown positive image in manganic oxide or manganese dioxide. The printed paper, or other material, is cleared of all the unchanged salts by washing in water, and will be hereinafter referred to as the print.

In order to produce a picture or image in pigment, I adopt either of the following methods:—

1. I take paper coated with pigmented gelatine commonly called carbon tissue, and proceed as follows:—

I dip the carbon tissue for about one minute and a half, or thereabout, in a weak solution of acetic acid and hydroquinone, or of acetic acid, hydroquinone, and ferrous sulphate, which I will hereafter refer to as the acetic solution. At the expiration of one and a half minutes, or thereabout, I take the washed print, and, having given it a coating of a two per cent. solution of gelatine, I plunge it under the surface of the acetic solution, and bring it in contact with the surface of the carbon tissue. I then draw the print (with the carbon tissue clinging thereto) out of the solution and squeegee them together on a flat surface. After surface-drying they are hung up to dry. When quite dry, I place the print, with its adherent carbon tissue, in cold water for about half-an-hour. It is then ready for development, which is performed by placing it in water at a temperature of 43° C., or thereabout, removing the backing of the carbon tissue, and washing away those parts not rendered insoluble by the action of the manganic oxide, thus giving an image in pigmented gelatine.

2. Or I coat the washed and dried print with a hot solution of pigmented or coloured gelatine, using preferably such a solution as is used in the preparation of carbon tissue, and, as soon as the gelatine coating is dry, I dip the print thus treated for about one minute in the acetic solution above referred to. I now hang the pigmented print up to dry, and, when thoroughly dry, I develop the image by dissolving in water, at a temperature of 43° C., or thereabout, those portions of the gelatine coating not rendered insoluble by the action of the manganic oxide.

In order to produce an image in aniline colours I dip the washed print in the following solution:—

Aniline hydrochloride ...	about	20	grammes
Sulphuric acid	„	2	c.c.
Water	„	300	„

which converts the image into a green colour. If the image is treated with a weak solution of ammonia, a purple image is produced; and, if chloride or bromide of copper be added to the above-described aniline solution, a dark blue image is the result.

Other substances, such as various phenol derivatives and amido-phenols giving colour on oxidation, will produce coloured images.

In preparing the sensitising solution mentioned above, I use by preference the following formula, coating the material twice with same.

The under-mentioned solutions are first prepared separately:—

A. A saturated aqueous solution of potassium bichromate, to which has been added as much boric acid as it will dissolve at a temperature of 16° C., or thereabout.

B. Manganous sulphate ...	25 parts to	100 parts	distilled	water.
C. Manganous chloride ...	25 „	100	„	„
D. Aluminium sulphate ...	25 „	100	„	„
E. Dextrine or gum-arabic	1 part to	2	„	„

To make a solution for sensitising paper or other material, the above-mentioned solutions are mixed in the following proportions :—

A.	10 parts
B.	4 „
C.	2 „
D.	1 part
E.	1 „

The following is a formula for the acetic solution already referred to; but so much depends upon the character of the negative and the constitution of commercial carbon tissue, that the ingredients may have to be modified in quantity to produce the best results :—

Magnesium sulphate ...	10 grammes
Glacial acetic acid ...	8 c.c.
Hydroquinone	2 grammes
Ferrous sulphate	·25 or ¼ gramme
Water	1000 c.c., or 1 litre

Other reducing agents may be used in place of the hydroquinone, such as pyrogallol, in some cases.

In the case of prints to be subsequently treated with pigmented gelatine in the form of carbon tissue, I claim the following advantages over other similar known processes, namely :—

1. The image is visible during the progress of printing, and when washed is permanent.

2. The picture being produced on the material, where it will permanently remain, does not become reversed in the operation, as in the present method of carbon printing.

3. No precaution need be taken to guard against the edges of the picture washing up during development.

4. As it is necessary that the chromic salts should be thoroughly washed out of the print before development, the hands of the operator do not come in contact with any deleterious solution.

5. No insoluble gelatine is necessary on the material to be sensitised.

In case of prints treated with aniline and other similar salts, I claim the advantage of simplicity of production and novelty.

Mr. Manly's claims are :—

1. A solution containing one or more of the light-sensitive compounds of chromium in conjunction with one or more of the manganous salts for the preparation of a light-sensitive surface for the production of photographic images.

2. A suitable material, such as paper, rendered sensitive to light by the application of a solution containing one or more of the light-sensitive compounds of chromium, in conjunction with one or more of the manganous salts, for the production of photographic images.

3. The production of photographic images in pigmented or coloured gelatine, by exposing the sensitive material described in Claim 2 under a negative or other screen to obtain a print, fixing such print by washing it in water to remove the unchanged salts, drying the same and bringing it in contact with pigmented gelatine in a solution containing acetic acid and a reducing agent such as hydroquinone, drying again, and developing the image by dissolving in hot water those portions of the pigmented gelatine which have not been rendered insoluble by the action of the oxide constituting the image.

4. The production of photographic images in pigmented or coloured gelatine by exposing the sensitive material described in Claim 2 under a negative or other screen to obtain a print, fixing such print by washing it in water to remove the unchanged salts, drying the same, coating it with a hot solution of pigmented gelatine, allowing the same to dry, dipping the print thus treated in a solution containing acetic acid and a reducing agent, such as hydroquinone, drying again, and developing the image by dissolving in hot water those portions of the pigmented gelatine which have not been rendered insoluble by the action of the oxide constituting the image.

5. The use of a sensitised paper or other material, such as described in Claim 2, giving an image in metallic oxide on exposure to light for the production of coloured images by treatment with aniline and other salts, capable of giving colour on oxidation.

6. The production of photographic images in oxides by the exposure of a surface rendered sensitive to light by the application of a solution containing one or more of the light-sensitive compounds of chromium, in conjunction with a metallic salt capable of being converted into an oxide by the action of light on the sensitive chromium compounds.

CHAPTER XLVII

THE POWDER PROCESS

UNDER the head of printing processes comes what is usually known as the powder process. On the Continent it has been used with very good effect for the production of prints on paper, though in England its more familiar application is the production of negatives for transparencies on glass. The *rationale* of the process is as follows:—

When a tacky body of an organic nature is brought in contact with potassium dichromate, and is allowed to dry as far as possible, and then exposed to light, it will be found that, owing to the oxidation of that body by the chromic acid, the tackiness will disappear in exact proportion to the intensity of the light acting on it. If a glass plate be coated with such a preparation, and be placed beneath a half-tone negative, the densities of the different portions of the negative will be represented by different stages of tackiness. A fine powder sprinkled over the exposed surface will adhere to the tacky portions in the ratio of the tackiness. Hence a picture will be built up which will be a counterpart of the negative, only reversed. From this it will be manifest that, in order to obtain a positive picture, a reversed positive must be employed; though a line engraving, for instance, may be directly copied by this method by allowing the back of the engraving to be in contact with the sensitive surface.

The following are the formulæ that have proved, in our hands, most successful:—

Obernetter's Formula.

Dextrine ...	... ...	1 drachm ...	55 *parts*
White sugar	... ...	1¼ „ ...	70 „

Ammonium dichromate	½	drachm	27 *parts*
Glycerine	2 to 8	drops	2 *to* 8 „
Water	3	ounces	1320 „

Or,

Woodbury's Formula.

Gum-arabic	1	drachm	55 *parts*
Glucose	¾	„	42 „
Glycerine	10	drops	10 „
Potassium dichromate	30	grains	30 „
Water	2	ounces	880 „

Whichever formula is employed, the solution should be filtered whilst warm, and be kept in a glass-stoppered * bottle.

A glass plate is next cleaned, and, if thought desirable, coated with a thin film of porous collodion, allowed to set, and then washed under a stream of water till all greasiness due to the solvents has disappeared. When drained, sufficient of No. 1 or 2 is taken in a clean glass measure, and allowed to flow over the surface two or three times. After pouring off the excess of fluid the plate is dried at about 150° F., or gently over a Bunsen burner or Argand lamp, etc. Whilst still warm, and before the surface has had time to re-absorb moisture, the plate is placed in contact with the transparency or negative from which it is desired to obtain a copy reversed as regards left and right, and placed in sunlight for two or three minutes, or in a bright diffused light for ten to fifteen minutes. On removal from the printing-frame a faint image will be apparent, should the printing have proceeded far enough. The film is now exposed to the air in order that it may imbibe moisture, and plumbago † is applied with a large, flat brush. The lights or shades are now represented by the graphite, according as a negative or transparency has been superimposed.

When the image has been fully developed, the superfluous powder is gently dusted away, and the film coated with tough collodion (that used for transferring films answering well). When well set, the plate is placed in water to allow the

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* A cork should not be used, as any extraneous organic matter is fatal to good results.

† The plumbago should be of the finest description; that used by electrotypers answers better than any other we have tried.

soluble gum and dichromate to dissolve out; and, if desired, the film may be detached from it by cutting round the edge with a sharp knife, and treating it as shown in the chapter on "Enamels." The film thus detached may be made to adhere to any support required—such as paper or glass—by giving it a thin preliminary coating of gelatine.

The application of this process to paper can be now understood. In practice, it is found advantageous to give it a good smooth sizing of gelatine previous to coating with the above. Ordinary albumenised paper, the albumen of which has been coagulated by heat and afterwards washed, may be substituted.

CHAPTER XLVIII

A PHOTOTYPE PROCESS

All other kinds of phototype processes except the heliotype process are, it is believed, those by which the gelatine film is printed from without removal from the glass plate. We give an outline of a process which has proved satisfactory in the hands of many.

Preliminary Coating with Albumen.—First of all, it is usual, though not absolutely necessary, to use a thick glass plate as the basis from which the print has to be produced, and this being so it is necessary to secure adhesion of the gelatine to it by some means or another. A usual plan is to grind the surface a fine grain, and then to coat it with the following solution :—

Albumen	3	drachms	165 *parts*
Water	2½	„	135 „
Ammonia	1½	„	80 „
Bichromate of potash	4	grains	4 „

The bichromate is reduced to powder in a mortar, and the ammonia and water added to it. The albumen, after being beaten to a froth, is allowed to subside, and the measured quantity added to the above solution. This solution is poured over the ground surface of the thick glass plate, which should be about three-eighths of an inch in thickness, care being taken that no bubbles are formed. The excess is then drained away, and the plate is allowed to dry spontaneously. When dry, this film is exposed through the *back of the plate* to light for from ten to twenty minutes. This hardens the surface of the albumen next the glass, and renders it insoluble, whereas the outer surface remains partially soluble.

Husnik avoids using this preliminary preparation by employing the following :—

Albumen	8 parts
Commercial silicate of soda	5 „
Water	7 „

These are mixed together and allowed to settle, and the clear liquid is decanted off, or, if necessary, filtered. Great care should be taken that no particles of dust get on the plate when coated. The plate is covered as with collodion, and allowed to dry after all excess has been drained away. It is then ready to receive the sensitive preparation.

Sensitive Gelatine Preparation.—The gelatine solution is made as follows :—

1.—Gelatine (Nelson's No. 2 flake) ...	1 ounce ...	1 *part*
Water	8 ounces...	8 *parts*
2.—Potassium bichromate	160 grains ...	1 *part*
Water	4 ounces...	12 *parts*

The gelatine is allowed to swell, and then dissolved, and the bichromate solution added. The temperature should be kept up to about 100° (38 C.), and the plates should be slightly warmed to receive this solution. It is difficult to say how much gelatine solution each plate should receive. The film should be very thin when dried, the thickness of a gelatine emulsion film being sufficient. For a 12 by 10 plate, about half-an-ounce of the solution should suffice. The reason of keeping the thickness of the film to a minimum is to prevent the relief, after printing and soaking in water, being too high, and at the same time, it is necessary that the film should be sufficiently thick to imbibe a sufficient quantity of moisture when damped for inking-in. The hardness of the film has something to do with the success of printing, as has also the "grain" of the gelatine after printing. A certain amount of very fine grain is necessary in order to obtain adhesion of the ink to the surface. The addition of ten grains to the ounce of tannin to the foregoing solution helps matters, but it must be added very cautiously, being dissolved in one ounce of water, and added with stirring. If the gelatine be too soft, a quarter of an ounce of isinglass may be used with advantage. To secure grain, in some instances oxide of zinc has been added, and also plates are immersed in alcohol after exposure to light and washing.

For drying phototype plates, M. Leon Vidal recommends a drying-box the form of which is due to Mr. Rogers. The general appearance it presents is given in fig. 173.

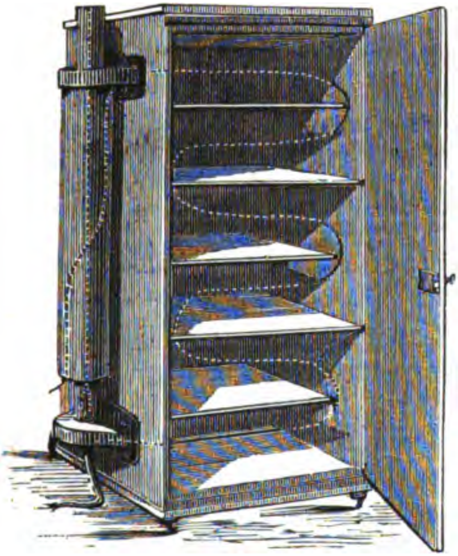

Fig. 173.

The section (fig. 174) of the box shows the general principles of the figure, but the exit pipe for the warmed air is at the top of the box instead of at the side. The drying-box may be of any dimensions. P is a one-inch piece of gas-piping standing on the box C, and through it a small pipe carrying a minute gas-nipple passes; it is soldered in air-tight at the bottom of C, and is connected by an india-rubber tube, I, with the gas; Z is a three-inch stove pipe, soldered up at one end, and open at the other, through which P passes; a small leather washer, W, makes the zinc tube air-tight at the top; D is an outlet tube passing into the top of the box, over the opening of which may be stretched muslin in order to arrest the entrance of all dirt into the interior. At K is a "light-trap," to exclude all light which might be reflected from G, the gas-jet; a current of warmed air thus perpetually circulates in the box B. The gas is lighted by raising the pipe P from off C, which is then replaced. The plate gradually dries after twelve to twenty-four hours.

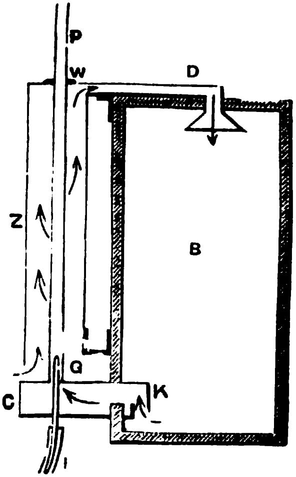

Fig. 174.

Printing the Image.—The image is printed as given in the heliotype process.

Major-General Waterhouse says:—"It is advisable to secure clean margins by shielding the borders of the negative by means of a mask cut out in yellow or brown paper, which should well overlay the edges of the printing-plates. The mask is laid on the glass of the pressure-frame, then the negative in its proper position (should this be a transferred film, it is advisable to place a glass plate between it and the mask, in order to secure the most perfect contact); the sensitive plate is then rubbed over with a little powdered soapstone, to prevent its adhesion to the negative, and adjusted in its place over the negative, covered with a sheet of black velvet or brown paper, over which a thick glass plate is laid, and, if necessary, a few sheets of thick paper to give a good strong pressure when the bars are shut down. The thick plate of glass has been found to give much sharper and more even contact than the usual backboard."

The amount of exposure to light varies from about ten minutes in the sun for a clear line subject, to from twenty-five to fifty minutes for a subject in half-tones, according to the subject and intensity of the light; but, as it is impossible to judge of the progress of the printing by inspection, it is necessary to use an actinometer as a guide to the exposure (page 423).

Whatever preliminary coating has been given to the plates, a slight exposure through the back of the plate should be given to avoid too great a relief. This exposure will be far less than with the heliotype process, as the film of gelatine is much thinner.

It is as well to carry on the second exposure under a piece of ground glass; otherwise, if there should be any scratches on the back of the sensitive plate, or on the glass of the pressure-frame, they will show as white lines on the print; after this the plate is taken out of the frame; a little tallow is rubbed round the edges to prevent water getting underneath and stripping the film; it is then plunged in water and thoroughly washed until all traces of bichromate have been removed, and is ready for printing.

Printing the Pictures in the Printing Press.—To ink-in the picture, the following plan may be adopted, which is that used in the heliotype process:—

Best lithographic chalk ink * should have been prepared with green oil, and be of the consistency of soft wax. The gelatine or other roller should be coated with this ink by rolling on a stone slab or slate. When coated, the roller is

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* All *inks* should be *very* finely mulled.

applied, evenly and smoothly, to the plate. Those parts acted upon by light will take the ink, whilst all others will repel it. If the picture be a half-tone one, a thinner ink of any colour made up with oil or Russian tallow may be used on another roller. This roller will not rob the plate of the first, on account of the thinness of the second ink, but will give detail in the high-lights. Paper is now placed on the plate, and, with a moderate pressure, a proof is pulled. Should white margins be apparent round the blackest shadows, or if the relief of the plate be too great, it is a sign that the surface requires "smashing down." This is done by placing bibulous or enamelled paper on the skin, and putting pressure on. As the film is so thin, the relief will never be very great. More ink is applied, and proofs are pulled till satisfactory results are obtained. The surface between each proof should be slightly damped with a sponge, and the excess of moisture got rid of * by the squeegee and blotting-paper. This keeps the whites clean as in lithography, and gives pluck to the resulting picture. If the whole of the picture be too deeply printed, a little dilute ammonia (one part to four parts of water) may be sponged over the surface till the over-printing is no longer visible. In order to keep clean margins to the prints, a mask is cut out of the shape required. The mask paper is prepared as follows:—Stout bank post is laid flat on a board, and boiled linseed oil is brushed over it; or similar paper may be coated with a wash of india-rubber dissolved in benzole. It is hung up by clips to dry, and is then ready for use. The mask, of course, is turned back between each inking-in of the picture.

We here add General Waterhouse's description of inking-in a picture on a plate somewhat similarly prepared. He says:—"When the exposure to light is considered sufficient, the negative and mask are removed, and the back of the sensitive plate is then exposed to light for about five or ten minutes, to thoroughly harden the gelatine, and prevent it from swelling too much in the after-process.

"The plates may be printed in the lithographic press, and then require to be fixed on a level stone with plaster of Paris. It has been found, however, more convenient, and in other respects better, to print them with vertical pressure in the

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* This should be done as quickly as possible, as, if not, the film is apt to become unequally damped, and give an unequally printed proof.

ordinary Albion press; and, in order to prevent their being broken, the bed of the press is fitted with two or three thicknesses of kamptulicon, besides a sheet of vulcanised india-rubber on which the plate rests. It is also desirable to place a sheet of white paper over the bedding, in order to enable the state of the plate, when it is being inked-up, to be better seen.

"The plate, having been well soaked in water, is laid on the press, and, after having been wiped to remove the excess of moisture, is inked-in, if a line subject, with an ordinary lithographic roller charged with an ink composed of lithographic chalk ink, thinned with a little olive oil, followed by a rolling with a smooth roller to clean away the superfluous ink; a mask of the required size is laid on the plate; over this comes the printing paper, covered with a piece of soft felt to drive the paper well into the hollows of the plate; the tympan is lowered, and the impression pulled in the ordinary way. The plate is then damped, and the work goes on in the same manner without difficulty.

"For printing in half-tones, however, the process is somewhat different.

"The plate is first inked-in by means of a small leather hand-roller charged with stiff ink (rendered stiffer, if necessary, by the addition of a little Canada balsam), which takes only on the deeper shadows; the half-tones are then brought out by filling-in with a smooth lithographic roller charged with a lighter and softer ink. Rollers composed of glue, treacle, soap, and catechu have been found useful in certain cases for inking-in the plates; but, on the whole, the lithographic rollers are preferred. The impressions are best when printed on enamelled paper; but a smooth glazed printing paper also seems to answer well.

"Before putting away the plates after printing, they are washed with turpentine, followed by a very weak solution of caustic potash, to remove all traces of the greasy ink; they may also be treated after this with a mixture of gum and glycerine with advantage. The following formula for preparing rollers will be found satisfactory:—

"*Preparing the Gelatine Rollers.*—The rollers are made of a solution of gelatine to which glycerine and castor oil are added. They are moulded in a cylindrical mould, on perforated wooden rods, similar to the manner of preparing ordinary printing rollers. A roller for a first ink is coated with gold size and the fluff of blotting-paper; a second ink roller remains with the gelatine surface to take up the ink. India-rubber rollers can also be obtained, which answer well. The great secret of producing a good heliotype is to have first-rate rollers at command.

"*Corrections.*—A point which seemed likely to greatly interfere with the extended use of the process was the difficulty of making corrections on the plates. I am glad to say that some experiments lately tried have shown that it is practical both to insert and to take out or clear up details on the gelatine films.

"The insertion of details may be accomplished by two or three methods. The first is by writing in the required additions on the dry plate with a pen or fine brush, using an ink composed of bichromate of potash, used alone, or slightly coloured with Indian ink or indigo. After the additions are completed, the plate is exposed to the light for ten minutes or a quarter of an hour, till the bichromate is thoroughly reduced, and may then be washed and printed as usual. In some cases the same object may conveniently be accomplished by brushing over the part with solution of bichromate of potash, allowing it to dry, and then printing-in the required details from another negative.

"Experiments have shown that details may be taken out by the aid of a solution of caustic potash or cyanide of potassium; and should a plate print dirty, it may be cleaned up and greatly improved by the use of a weaker solution of the latter substance.

"It often happens that the plates show too much relief in the lights, and that the ink will not take readily on the shadows or lines represented by the deepest hollows. This relief may be reduced by brushing the plate over with dilute nitric acid, one-sixth or weaker. The plate is then washed, and, on inking-in, the ink will take readily in the lines or hollows."

Varnishing Prints.—If thought necessary, the prints may be varnished, after pulling, by a water-varnish. This is made by dissolving shellac in boiling water, to which a little ammonia has been added. As the shellac dissolves, more is added, stirring the solution the whole time. From time to time more ammonia and shellac must be added, till the varnish, on drying, leaves a brilliant surface. The varnish is filtered, and applied to the print with a flat brush.

CHAPTER XLIX

PHOTO-LITHOGRAPHY AND ZINCOGRAPHY

PHOTO-LITHOGRAPHY is an important branch of photography where the rapid copying and multiplying of large subjects is in question, and requires much care and dexterity to carry out. It is rarely to be found that the process is worked satisfactorily by a beginner, but that constant practice will render it easy.

The part that is played by photography in photo-lithography is the obtaining from a negative a print * in greasy ink which may be laid down upon the ordinary lithographic stone or a zinc plate.

Southampton Plan for Preparing Transfers.—Make the following mixture:—

Potassium dichromate ...	2 ounces	2 *parts*
Nelson's fine-cut gelatine ...	3 ,,	3 ,,
Water	50 ,,	50 ,,

The dichromate is dissolved in 10 ounces of water, and added to the 40 in which the gelatine, after proper soaking,† has been previously dissolved by the aid of heat. Good bank-post paper (very grainless) of a medium thickness is selected, and if this cannot be obtained, ordinary thin paper may be substituted, and cut into sheets a little bigger than the negative to be printed from. The solution is strained and poured into a dish through flannel.

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* Called a transfer.

† The gelatine should soak in water just sufficient to cover it, and then the remainder of the water should be added in a boiling state.

The temperature is kept up by placing the dish upon a tin box containing hot water, and kept warm by a spirit-lamp placed beneath it.

The paper is floated for about three minutes, and hung up by two corners in a room to dry which is non-actinically lighted, and is perfectly free from dust. When dry, the paper must be floated again as before. The sheets should be hung up from the opposite corners to those by which they were hung after the first flotation. Should it be considered desirable to coat the paper with gelatine first, and then sensitise, the dichromate may be omitted from the foregoing formula. The sensitising is then effected by floating the prepared paper for one minute on a cold solution of—

Potassium dichromate ...	1 ounce ...	1 *part*
Water	15 ounces ...	15 *parts*

In both cases it is well to pass the sensitised paper through a copper-plate or lithographic press, as a fine, smooth surface is thus given it. The paper may be subsequently floated on a solution of albumen and bichromate of potash, made as follows:—

Albumen	3 dr. ...	17 *parts*
Ammonia	10 grains ...	1 *part*
Potassium bichromate ...	10 „ ...	1 „
Water	5 dr. ...	28 *parts*

The use of this will be apparent when the development of the transfer is considered.

The sensitised paper will keep from about a week in cold to one day in hot weather.

The negative should preferably be perfectly opaque in the whites, and no clogging or deposit must mar the transparency of the lines. It will be found that great pressure is required in the printing-frame to bring the paper and the negative in close contact throughout. The difficulty is increased considerably if the plates are not perfectly flat; hence, for these negatives, patent plate is recommended.

The amount of exposure to be given requires great judgment. With paper of a most sensitive character, and with a negative in which the whites are extremely dense, and the lines perfectly transparent, from half a minute to two minutes' exposure in bright light will suffice, whilst an hour may not be too long in dull weather. The surest indication of proper exposure is that the lines should appear of a dark reddish-brown on a yellow ground. Should a negative be weaker in some parts than in others, the weak parts may be shaded by tissue paper, or paint applied on its film side.

The prints have now to be coated with greasy ink. At Southampton the following formula for the ink is used :—

Lithographic printing ink	8 ounces
Middle varnish	4 „
Burgundy pitch	3 „
Palm oil	½ ounce
Wax	½ „
Bitumen	1 „

The ink and varnish are first well ground together with a muller or stone slab. The Burgundy pitch is next melted over a clear fire till the water is driven off. The wax is next added to it in small pieces, and finally the palm oil. These are well stirred together. When properly heated, the vapour from the mixture should catch fire if a light be applied, and then the bitumen is added, and the contents of the pot ignited again. The ink and varnish are now added, little by little, the stirring continuing the whole time. The pot is now taken off the fire, and when the contents are cooled they are poured into tins for storage. The condition of the ink is of the greatest importance. It must not be too soft, otherwise the sponge used in development will become clogged. If the ink be too hard, it will be difficult to develop at all; in this case more palm oil should be added.

To commence inking-in the print, a small quantity of the ink should be taken, and laid upon a flat stone slab, and melted with turpentine sufficient to give it the consistency of honey. This is well worked with a lithographic roller on a smooth stone, or its equivalent, to a fine, even surface. A print is now taken and laid face downwards upon this inked stone, and is passed once or twice through the lithographic press. On carefully raising the paper, it will be found to have taken a fine layer of ink, through which the detail will be faintly visible by transmitted light. The coating of ink may also be given by a sponge or hand-roller, the paper being pinned firmly on to an even board, face uppermost. The finer the layer of ink, the better will be the developed print. These operations should, of course, be carried on in non-actinic light.

The print is now *floated, inked surface uppermost*, on water of about 90° Fah. (33° C.). It is allowed to remain on this till the lines are seen in *bas-relief* on a swollen-up ground. It is next transferred to a sloping zinc or glass plate, and warm water of about 150° (67° C.) is poured gently over it. The soluble gelatine is removed by *gently* rubbing with a very soft sponge; but should the inked soluble gelatine not leave the paper entirely at this stage, the prints should be *soaked* in warmer water for an hour, when the sponging should be repeated. When the sensitised gelatine is moistened it becomes almost insensitive; consequently those operations may be performed in ordinary weak daylight. A constant flow of water from the sponge must be kept up to remove the inky gelatine after it is loosened, otherwise stains on the paper ground may result. It should be borne in mind that

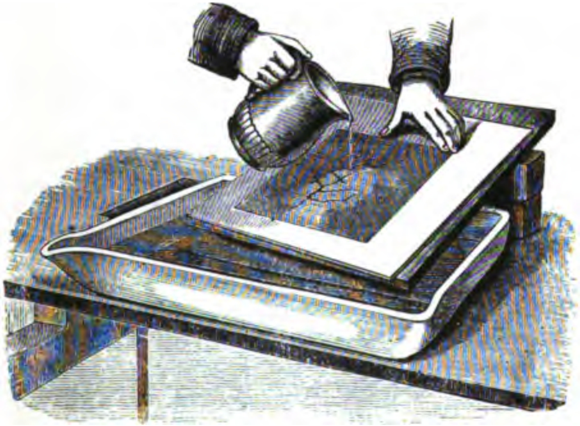

Fig. 175.

the utmost care is required in the sponging; if the sponge be roughly handled, the fine inked lines will be removed, and spoil the print for transfer.

The prints, when freed from the soluble gelatine and ink, should be well washed in dishes of cold water, and hung up to dry. They are then ready to transfer to stone or zinc, but it is better to leave them a day before the transfer is made.

If an albumen surface has been given to the transfer, the paper may be developed by floating on cold water till the gelatine is swelled as before. The application of cold water from a jug, and a gentle sponging, will remove the soluble albumen, and with it the ink.

To make a Transfer by Papyrotype.—Any tough paper is coated with a fine layer of gelatine, and subsequently treated with chrome alum or alum. It then receives another coating of gelatine of the same formula given for the Southampton method, substituting flake gelatine (for cheapness' sake) for the fine-cut. The printing is not carried on to such an extent as in that method, but the lines must appear of a delicate fawn colour on the yellow background. After withdrawal from the frame, the print is drawn through cold water, and is then squeegeed down on to a smooth zinc or pewter plate. If found necessary, the edges may be secured by strips of paper and india-rubber solution, as for the heliotype process. The superfluous water is then blotted off, and a gelatine roller (of not too adhesive a character) is charged with ink. At the photographic department of the Royal Arsenal, they use what is termed a velvet roller, which is a lithographic roller covered neatly with a piece of velvet. This application of velvet seems at the time to have been regarded as a discovery, but it was used in the early days of heliotype, and discarded as not cleaning the whites of the picture sufficiently, being not quite adhesive enough. Our readers may try the velvet roller if they fancy it. It is necessary that the seam be very carefully made, as otherwise it shows marks in rolling up a transfer. It answers very admirably when the whole surface of the paper has to be inked over, and the whites then sponged away, and could be adopted in the Southampton mode of preparing a transfer. The ink is made as follows:—

Best lithographic chalk ink	4 parts
Palm oil	1 part

A small portion of the ink is spread upon a stone slab as in ordinary lithography, and after the roller has taken an even coating, it is applied to the paper. The gelatine has only absorbed water where it has been unacted upon by light; consequently, the lines alone will take the ink, the whites remaining free. After the paper has been well charged with ink, it may be necessary to pass the roller smartly over the surface to remove any scum that may be adherent. The finished transfer will be found of the most delicate character, and possessing great sharpness.

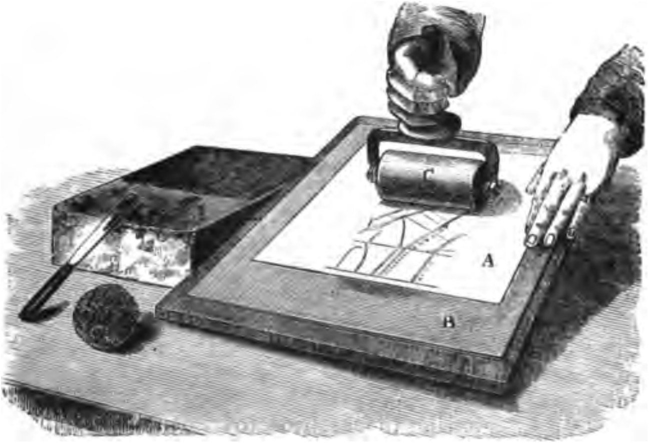

Fig. 176.

It is essential that but very little of the bichromate of potash should leave the paper, as the success in transferring mainly depends upon its presence. The transfer print is hung up to dry, and is then again exposed to light. The whole surface now becomes insoluble, and on re-damping, previous to placing on the stone, it has no tendency to stick, nor will the gelatine be squeezed away by the pressure of the scraper in the press. There will still, however, be sufficient adhesiveness left to retain the paper in position. It will be noticed that this process has the following advantages:—

1st. The ink which forms the lines is not left on ridges of gelatine, as in the Southampton method.

2nd. There is no danger of removing the ink from the fine lines.

3rd. The ink may be applied till a satisfactory result is obtained.

4th. Two inks may be used of different consistencies; the thick ink will give solidity to the thick lines, whilst the fine lines will take a thinner.

5th. The surface of the transfer will have no tendency to slip, as the whole is partially adhesive.

General Waterhouse's Process.—In the Surveyor-General's Office in India, General Waterhouse found that papyrotype did not come up to his expectations, probably owing to the heat of the climate, and he introduced a modification of the Southampton method, a description of which is taken from a communication to the Asiatic Society.

Paper is coated with two coats of gelatine and potassium dichromate, as in the Southampton method, and is put away to harden and to become insoluble. When required for use, it is coated with a mixture of gelatine and potassium dichromate of about one-third the usual strength, and is then exposed to light, and inked in the usual way.

Instead of allowing the gelatine to harden by keeping, the hardening action may be hastened by allowing the light to act on the back surface for a minute or two. This may be done either after the print has been obtained, or after the preliminary coating has been given to the paper. It has been found that this method has the advantage that a base of insoluble gelatine remains on the paper and retains the finest lines, whilst the fresh coating preserves the clearness of the ground. If the underneath gelatine be not well hardened, the gelatine tends to stick to the stone or zinc, and the soft gelatine is liable to spread over the lines and to prevent their transfer. The ink is removed by cold water and a sponge, leaving the lines crisp, and the space between them free from scum.

Preparation of the Stone and Zinc Plate, and Mode of Transparency.—It is not proposed to give a detailed description of the apparatus for lithography or zincography, as a respectable manufacturer will supply them of a proper character.

Both lithography and zincography depend on the property that a calcareous stone or mulled zinc plate possesses for absorbing or holding water, and on the fact that the grease is repelled by water; thus, where there is grease on a stone or zinc plate (present through accident or design) the water is repelled. If a roller now be charged with greasy ink, and passed over the surface whilst still damp, the greasy ink will "take" in those portions where grease was originally on the surface, whilst the other portions remain unaffected. The slightest trace of grease on the plate is sufficient to attract the ink from the roller.

Preparation of the Stone.—To prepare a lithographic stone for taking the transfer from a drawing, if the surface be uneven, or if a drawing has previously remained on for a considerable time, it may be necessary to grind it down, either by a stone or by an iron levigator. In both cases fine silver-sand is sprinkled between the two surfaces, moistened with water. When the old work is removed, and the surface level, it is thoroughly washed with clean water, and polished with soft pumice-stone. The pumice-stone is moved backwards and forwards till all grain is removed, when it is again washed with a sponge and water, and finally brightened up with snake-stone. After another washing it is allowed to dry, when it is ready to receive the transfer. The polishing with pumice and snake-stone will take about a quarter of an hour.

Preparation of Zinc Plates.—The zinc plates are supplied by manufacturers, of proper weight, and ready planished. They should be about 10 B. W. gauge. To be prepared for receiving a transfer, they must be grained. Brass-founders' moulding sand is the best form of sand to use, as others, particularly silver-sand, are apt to scratch the plate; and, prior to use, the sand is sifted through a fine sieve of about 150 holes to the linear inch. A zinc muller is used to grind the surface after the sifted sand (moistened to the consistency of a cream with water) has been sprinkled on the surface. It is worked slowly round and round with a spiral motion, till the surface after washing appears of a uniform dull grey tint. Any traces of previous work must be obliterated, and all scratches must be ground out. The mullers should be kept free from all accidental grit, and be carefully cleaned before use. The zinc plate, whilst mulling, may be laid on any flat surface. A plate should be mulled immediately before use.

Transferring to Stone or Zinc.—The stone is slightly warmed either before a fire, or, what is more expeditious, by pouring over the surface a kettleful of boiling water. The heat in this latter case dries the stone, and leaves it sufficiently warm, though there is a danger of the heat being too evanescent. The transfer is *slightly* damped, either by a moist sponge,* or by damping a sheet of blotting-paper, which is placed at the back.

Whilst this is taking place, the stone is placed on the bed of the press, and the first operation is to ascertain that the scraper is perfectly true. Should it not be so, it may be adjusted by placing a piece of sand-paper on a perfectly flat surface, and rubbing it down till it is perfectly level. The stone should now be "pinched" by the lever between the bed and the scraper, a piece of clean paper protecting its surface from the leather tympan. If the same amount of pinch be apparent at all parts of the stone, it is ready for use. If one end has less pinch than the other, the former must be raised by laying under it a few folds of paper, taking care that the folds gradually taper off as they approach the centre of the stone. The stone must next be passed two or three times through the press, in order that it may take its final bearings, after which the transfer is laid on the stone by two corners, and a couple of sheets of paper † are laid over it. After the tympan has been brought gently down, the stone is passed through the press two or three times. The amount of pinch given should be light for the first pull, it being increased for each subsequent one. The tympan is now raised, and if the transfer adhere tightly to the stone the scraper may be reversed, and the stone is passed through the press a couple of times more. In order to remove the transfer paper it may be necessary to soak it with water. This done, the surface of

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* The top surface of the transfer should never be sponged.

† Preferably a piece of transfer paper.

the stone is moistened with gum-water and allowed to dry and cool. This is most important, as if it be used too fresh or whilst warm, the lines may spread, and give coarse and broken work.

The stone is fixed on the press, and the gum is washed off with a soft sponge, and the moisture distributed with a damping or cheese cloth. Ordinary lithographic ink having been worked to the consistency of honey, a little is laid on the roller and worked about on the ink slab till a fine, even layer is spread over its surface. *Whilst the stone is moist* the roller is passed over it from time to time, fresh surface being brought to bear on the work. By this procedure it will be found that the lines take the ink. If a slight scum appears while rolling, it is probable that the stone is not sufficiently damp. A fresh application of the sponge and damping cloth, and a small roll, will lift it, leaving the surface clean. The stone is next slightly etched, to prevent spreading of the lines. A very dilute solution of nitric acid in water effects this. A sponge moistened with this should be passed over the surface, and after leaving it for two or three seconds, fresh water should be applied with the damping cloth. A little gum-water is then applied, wiped off, and the inking proceeded with again. It may happen that all portions will not take the ink alike—that portions are weaker than others; in this case, over those parts should be spread thick gum, and *through* it should be rubbed a little palm oil, spread on a small square of cloth. This *generally* gives the required intensity. Impressions are now pulled, inking-in between each.

For zincography the process is very similar; the transfer is damped and passed through the press as above, the zinc plate being screwed on to a flat block of hard wood, so as to lie evenly and to be of sufficient height on the bed. When the transfer is removed the plate is well washed, and fanned dry. An etching solution is made thus:—

Decoction of galls ...	1 quart ...	13 *parts*
Gum-water	3 quarts ...	40 ,,
Phosphoric acid ...	3 ounces ...	1 *part*

The decoction of galls is prepared by soaking four ounces of bruised Aleppo galls in three quarts of cold water for twenty-four hours; the water and galls are then boiled together and strained. The phosphoric acid is prepared by placing sticks of phosphorus in a bottle of water, the ends of the sticks being exposed to the air for some days. The etching solution is brushed on the plate with a broad brush, and allowed to remain a few seconds; the excess is wiped off with a cloth, and the zinc plate is fanned dry. It is then washed and rolled up as before. The first few impressions, either from stone or zinc, are generally feeble, and may have to be rejected.

A Gum Process.—Take Rives paper, and brush over it a solution of—

Picked gum-arabic	25 grains
Potassium dichromate	85 ,,
Water	1 ounce

Hang it up to dry. This will be accomplished in about half-an-hour in warm weather.

The sheet of paper must be placed under the negative as usual, and exposed to the light. When every detail is clearly seen, the paper should be withdrawn.

Take ordinary printing-paper, and soak alternate sheets in water, blotting the excess of moisture off in blotting-paper. Make these in a pile (about six sheets of moist and dry will be sufficient). Place the printed paper on the lithographic stone or sheet of mulled zinc, place a dry sheet of paper on its back, and then on it place the pile of damped paper. Finally, place a sheet of zinc or other flat surface on the top. The stone or zinc plate and its load should next be pressed under an ordinary book-binding press, and a considerable pressure brought on to it. It should be left under this for half-an-hour.

The paper is then removed from the stone. Those parts of the gum which were rendered insoluble will leave the stone with the paper, the remaining portions adhering to it. After thorough drying away from light, a little oil is poured or brushed over the surface. The gum protects the white portions of the prints from its action. The stone may be cleaned from the gum with a sponge and tepid water, and the ordinary lithographic process may then be proceeded with.

The process is simple, the drawback being that the gum penetrates to a considerable depth through the surface of the stone, rendering the preparation for fresh work tedious.

Photo-Lithography in Half-Tone.—The photo-litho preparation process, which is the best we know, is that worked out by Sergeant-Major Husband, R.E., and we give it as described in the *Photographic Journal*:—

This process has been named papyrotint, being a modification of Captain Abney's improved method of photo-lithography, named papyrotype. It is specially adapted for the reproduction of subjects in half-tone, such as architectural drawings in monochrome, or subjects from nature, and it is inexpensive. Its advantages over other methods of half-tone photo-lithography are, that a transfer can be taken in greasy ink, for transfer to stone or zinc, *direct* from the negative, however large, without the aid of a medium, the grain or reticulation being obtained simply by a chemical change. The transfer paper being in direct contact with the negative, the resulting prints are sharper than by those processes where interposed media are used; whilst the same negative will answer either for a silver print, platinotype, or a transfer for zinc or stone. The advantage of being able to use a non-reversed negative is very great, now that gelatine plates have so largely superseded those made with collodion.

The method of manipulation is as follows. Any good surface paper is floated on a bath composed of—

Gelatine (Nelson's flake)	8	ounces
Glycerine	1½	„
Chloride of sodium (common salt)...	2	„
Water	50	„

Great care should be taken that the solution is not over-heated, and that the paper is coated without bubbles. It is then dried in a temperature of 60° Fah. The paper will take about ten hours to dry, and in this state will keep for years. When required for use, it should be sensitised by floating or immersing in a bath of—

Bichromate of potash	1	ounce
Chloride of sodium	½	„
Ferricyanide of potassium	100	grains
Water	30	ounces

This need not be done in the dark-room, as the solution is not sensitive to light.

The paper, after sensitising, is dried in a temperature of 70°, and in a dark-room. When dry, it is exposed under any half-tone negative in the ordinary printing-frame. It is preferable to print in sunlight, and, for negatives of medium density, an exposure of three minutes is required; but the exposure will vary according to the density of the negative. The correct time of exposure can best be judged by looking at the print in the frame. When the image appears on the transfer paper of a dark fawn colour on a yellow ground, the transfer is sufficiently printed. It is put into a bath of cold water for about ten minutes, until the soluble gelatine has taken up its full quantity of water; then taken out, placed on a flat piece of stone, glass, or zinc plate, and the surface dried with blotting-paper.

The action of the light has been to render the parts to which it has penetrated through the negative partly insoluble, and, at the same time, granulated. A hard transfer ink is now used, composed of—

White virgin wax	½ ounce
Stearine	½ ,,
Common resin	½ ,,

These are melted together in a crucible over a small gas-jet, and to them are added 4 ozs. of chalk printing-ink, and the mixture reduced to the consistency of cream with spirits of turpentine. A soft sponge is saturated with this mixture, and rubbed gently over the exposed paper (in this stage the nature of the grain can be best seen). An ordinary letter-press roller, charged with a little ink from the inking-slab, is then passed over the transfer, causing the ink to adhere firmly to the parts affected by the light, and removing it from the parts unacted upon. It will be found that with practice, rolling slowly and carefully as a letter-press printer would his forme, the ink will be removed by the roller according to the action that has taken place by light, leaving the shadows fully charged with ink, and the high-lights almost clear, the result being a grained transfer in greasy ink. The transfer is next put into a weak bath of tannin and bichromate of potash for a few minutes, and when taken out the surplus solution should be carefully dried off between clean sheets of blotting-paper. The transfer is then hung up to dry, and, when thoroughly dry, the whole of the still sensitive surface should be exposed to the light for about two minutes. A weak solution of oxalic acid should be used for damping the transfer (about 1 in 100), and this should be applied to the back of the transfer with a soft sponge. After it has been damped about four times, it should be carefully put between clean sheets of blotting-paper, and the surplus moisture removed. A cold polished stone is then set in the press, and after everything is ready, the transfer is placed on the stone and pulled through twice. The stone or scraper is then reversed, and the transfer is again twice pulled through. A moderate pressure and a hard backing sheet should be used, care being taken not to increase the pressure after the first pull through. The transfer is taken from the stone without damping, when it will be found that the ink has left the paper clean. Gum up the stone in the usual way, but if possible let the transfer remain a few hours before rolling up. Do not wash it out with turpentine, and use middle varnish to thin down the ink.

It should have been mentioned that varying degrees of fineness of grain can be given to the transfer by adding a little more ferricyanide of potassium in the sensitising solution, and drying the transfer paper to a higher temperature, or by heating the paper a little before exposure, or by adding a little hot water to the cold water bath, after the transfer has been fully exposed; the higher the temperature of the water, the coarser the grain will be. The finer grain is best suited to negatives from nature, when a considerable amount of detail has to be shown.

The coarse grain is best for subjects in monochrome, or large negatives from nature, of architecture, etc., where the detail is not so small. Even from the finer grain several hundred copies can be pulled, as many as 1200 having been pulled from a single transfer, and this one would have produced a great many more if required.

CHAPTER L

PHOTO-RELIEFS AND PHOTO-ENGRAVING

Photo-Reliefs.—The production of satisfactory photo-reliefs of etchings, etc., has long been a desideratum in the printing trade, and many attempts have been made to secure such. The following answers well for their production in zinc.

A transfer in hard transfer ink from a negative is made as if for lithography and zincography. A one-eighth of an inch zinc plate is then thoroughly mulled as described at page 461, after which it is rubbed down to a smooth surface with pumice, and then with stick charcoal. The appearance of the plate should be such as to be almost polished, and all visible grain should be absent, particularly if the work to be reproduced be fine. The transfer is then placed on it, and passed through the lithographic press in the ordinary manner, and a good firm impression left on the prepared surface. The plate is now dusted with fine resin or colophony (the dust being passed through a muslin bag to prevent any lumps adhering to the plate), all that does not adhere to the greasy ink being blown off. A solution of—

Hydrochloric acid	1 part
Water	500 to 750 parts

is next prepared, and placed in a flat dish which is sufficiently large to hold the plate, and which can be rocked mechanically. The solution should be of such a depth that when the dish is fully tilted in one direction the surface of the plate should be a little more than half bare. The surface of the zinc bearing the picture is next flooded with a dilute solution of copper sulphate (10 grains to the ounce), and a fine black deposit of precipitated copper is left.

In this stage we have a zinc-copper couple, the contact between the two metals being so complete that the voltaic action is able to decompose a variety of liquids hitherto not easily acted upon. The coppered plate is immersed in the acid solution, and an immediate evolution of hydrogen shows that an action is taking place, the zinc being gradually attacked where the copper is opposed to it. It should be remarked that the acid solution is so dilute that it has no susceptible effect on uncoated zinc, hence those portions covered by this greasy, resinous transfer ink are not acted upon. The dish containing the acid should be constantly rocked to cause the bubbles of gas to disappear, and on this rocking depends the success of the process. After twenty minutes in this solution, the slow evolution of hydrogen will show that the acid is nearly exhausted. The plate should then be withdrawn, and washed under the tap. It should next be warmed to soften the ink and the resin, and more ink should be rubbed in the lines, as is done in rubbing up a lithographic impression. The dusting process is again resorted to as before. The copper solution is applied, and after washing the zinc is again immersed in an acid solution (this time of double strength of the foregoing), and the same motion given to the dish. These operations are again and again repeated, the warmed ink and resin gradually running down the raised lines and filling in the close spaces. When a sufficient depth is given to the close lines, the large portions of the block which should print white may be sawn out with a fine saw. The zinc relief is then mounted on a wooden block for printing purposes. When printing off large numbers, zinc is liable to damage, and printers seem to object to this metal. Electrotypes may be taken from the zinc relief, and, when faced with steel, leave nothing to be desired.

It should be remarked that the employment of copper prevents electrical action in the zinc when iron or other impurities are present, hence the metal may be that ordinarily to be obtained in commerce. The most successful worker in zinc, as far as the writer knows, is Gillot, of Paris, many of whose productions are undistinguishable from the best woodcuts. The economy of this method of producing relief blocks is the fact that two or three square feet of them may be executed at the same time, very little additional labour being required.

A very short way of obtaining blocks of relief printing is by treating a lithographic stone in a similar manner (omitting the copper solution), and using a hot iron for melting the ink and the resin. A mould is obtained from this in wax, paraffin, or gutta-percha, and an electrotype taken. Great depth is more easily obtained on a lithographic stone than on zinc if the manipulations are carefully attended to. Constant practice is required in these processes to ensure success.

Photo-Reliefs direct from the negative.—Of late years the use of the transfer for making these blocks has been largely abandoned, the surface of the zinc or copper plate is coated with a light-sensitive compound upon which the image is printed direct from the negative.

As it is necessary that the negative for this purpose should be reversed, that is, that when the film side is held towards the observer, the image should appear the right way round, special means must be adopted to secure this.

Reversing mirrors or prisms may be used, and apart from the question of expense, there are good reasons why the former should be chosen.

Although open lined work may be fairly well reproduced upon the photo mechanical dry plates sold for the purpose, the use of the wet collodion process is a necessity for best results, particularly when the lines in the drawing are fine and close together.

An intense light, preferably that of the electric arc, is desirable in making the exposure. In developing the plate no deposit of silver should be allowed to form upon the lines, which after fixation should be absolutely free from veil. Density may be obtained by means of the cupric bromide intensifier, formula No. 8, or by Eder and Toth's method, formula No. 9, Chapter XVIII.

The next stage is to prepare the zinc plate, which may be obtained ready polished from the dealers. The plate is freed from grease by scouring with prepared whiting moistened with methylated spirit, and applied with a tuft of cotton-wool.

Place the cleaned zinc plate in a porcelain dish raised at one end with a sufficient quantity of the following solution in the lower end of the dish :—

Alum (powdered)	1 ounce
Water	20 ounces
Nitric acid	1 drachm

Lower the dish to allow the solution to flow evenly over the plate to avoid markings, and keep it rocking gently for about a minute till the plate assumes a pearly-grey tint. Remove the plate and hold it under the tap, rubbing the surface with a piece of cotton-wool as the water flows over it to remove the scum. Wipe the back of the plate and fix it to the pneumatic whirler—an instrument which resembles a mechanical egg-whisk with an india-rubber holder attached—and pour upon it a little of the following solution :—

Albumen	1 ounce
Water	10 ounces
Ammonium bichromate	80 grains

These ingredients are placed in a bottle with some pieces of broken glass, well shaken up and allowed to stand for an hour or two and filtered through cotton-wool.

The first application of the albumen solution is poured over the entire surface of the plate and poured off. A second coating is then given the plate, which is turned upside down in the sink and whirled at a moderate speed for half-a-minute or so; the plate is removed from the whirler, any excess of moisture blown off with the mouth, and is then dried gently over the stove.

The operation of printing must be conducted in a strongly-built printing-frame fitted with a stout sheet of plate glass.

Springs, however strong, are quite insufficient to bring the plate into close contact with the negative. Pressure must be applied to the back-board either by screws or by wedges—the former are preferable.

Exposure must necessarily be judged by an actinometer—various patterns are described in the chapter on Carbon printing.

When the plate is correctly printed it is inked with a roller charged with photo-transfer ink till it appears of a dark-grey tint. It is then placed in a dish of clean cold water, and the ink not forming the image is gently removed with a pledget of cotton-wool. After drying, the plate is dusted over with a mixture of resin and bitumen ground to a powder.

The following formula recommended by M. Henri Calmels will be found suitable:—

Bitumen of Judea (pure)	60 parts
Black pitch	25 ,,
Resin	15 ,,

These are melted together in an iron pot, poured upon a slab to cool, and reduced to an impalpable powder.

When the inked image is covered the surplus dust is brushed off, and the plate is heated upon a slab of metal over the stove till the powder melts and is incorporated with the ink, but must not be over-heated or the lines will spread.

The first etching bath may conveniently be—

Nitric acid	1 part
Water	100 parts

Before placing in the bath the underside and edges of the plate should be varnished to resist the acid. Etch for a minute or so, rinse and dry the plate, and examine for broken lines and other faults, which must be made good by applying with a pen a little of writing transfer ink rubbed down with water to the consistency of oil.

The plate is then etched in successive baths, each a little stronger than the previous. Between each etching the plate is rinsed, dried, inked up, and heated to make the ink run down the sides of the lines as in the transfer process preceding this, and the final operations of mounting, etc., are identical with those previously described.

Photo-Engraving.—There are various methods of producing photo-engravings which are employed by different firms; but, so far, the best seems to be that based on the original process of photography, viz. on the action of light on asphaltum or chloroform, and a thin coating given to the copper plate by flowing it over as collodion would be. When dry, the colour of the copper should be visible through the coating. The plate is then exposed behind a film, and after half-an-hour's positive sunshine, or its equivalent in diffused light, it is developed. The developing consists first in softening the soluble portion of asphaltum with olive oil, to which subsequently a little turpentine is added. This gradually dissolves away the asphaltum, and leaves the lines bare and ready for the action of the etching fluid.

The development must be very gradual, and the turpentine and oil washed away with water directly the lines are bare, otherwise the action of the solvents will continue on the parts which have been acted upon by light, and the image will gradually disappear.

The etching solution will be as follows :—

Potassium chlorate	1 part
Hydrochloric acid	10 parts
Water	48 ,,

After the developed plate has been immersed in this solution a short time, the weakest lines will appear to be etched, the stronger lines taking the " bite " quickest. When the former are judged to be of sufficient depth, the asphaltum is removed by benzole, and the plate is ready for the copper-plate press.

Photo-Engraving in Half-Tone.—The processes employed for this purpose are more or less secret. Fox Talbot was the first to introduce a plan by which it could be effected. His plan was as follows. A transparency is made from a negative, and this is placed in contact with a copper plate, which is coated with—

Gelatine	¼ ounce ...	1 *part*
Saturated solution of potassium dichromate ...	1 ,, ...	4 *parts*
Water	10 ounces ...	40 ,,

In Talbot's instructions it was directed that the plate should be dried by means of heat; it may, however, be dried spontaneously. A very thin coating of gelatine is all that is required. When the printing is complete, a solution of camphor and resin in chloroform is made, and the surface coated with it. The chloroform evaporates, and leaves a film of resin and camphor. The plate is gently warmed, and the camphor evaporates, leaving the resin in minute particles adhering to the surface of the gelatine. The plate is next etched by a solution of ferric chloride and water, viz. :—

Saturated solution of ferric chloride ...	6 ounces
Water	1 ounce

A small quantity of this is evenly brushed over the plate, and in about a minute the etching commences, and is seen by the etched parts becoming darker. It spreads rapidly, and the details of the picture gradually appear. The greatest care is requisite in having the etching solution of the right strength. If the etching commences too rapidly, the solution must be kept more saturated with the ferric chloride, less water being added. If the strength be too great, the etching commences but slowly. The use of the powdered resin is to give a grain to the plate, and in one process Fox Talbot used fine netting to give the desired effect in printing. In both cases the etching fluid did not act where such grain was formed. When the etching is considered complete, the plate is dried with a cloth, and all action stopped by immersing in water. We recommend that to the water a little sulphite of soda be added, as this reduces the iron salt to the ferrous state, and thus stops all action.

Goupil's process is a secret one, and therefore we cannot say emphatically on what principles it is based. It seems to be, however, founded on making a gelatine image, and then electrotyping it.

The modification of Fox Talbot's process, known as the Talbot-Klic process, is worked commercially to some extent in this country, and since the lecture and demonstration given by Mr. Herbert Denison to the Affiliated Photographic Societies, it has been taken into favour by some amateur workers.

The operations as commonly worked are as follows :—

A planished and polished copper plate is cleaned from grease by the application of a caustic alkali, and any tarnish which may be present is removed by a brief immersion in dilute nitric acid, the plate is rinsed and receives a final polish with prepared chalk moistened with a little dilute ammonia and applied with a tuft of cotton-wool. Care must be taken that no grit is allowed to touch the surface of the plate, as even the finest scratches will be apparent in the print. The plate is again rinsed and dried and is then ready to receive the ground.

The object of the ground is to give a grain to the plate which will hold the ink. In the absence of this grain, the etched image would take the form of shallow depressions from which the ink would be wiped out and the print would be a formless blur.

In the Talbot-Klic process the ground is applied to the plate before the gelatine image is laid down, and in place of the solution of camphor and resin in chloroform used by Talbot it is customary to dust the plate with finely-ground bitumen or resin.

A box to hold the plate during the operation of graining is a necessity. A very convenient form of box in which the dust is stirred up by a revolving fan may be obtained from the dealers in engravers' requisites, but when the process is only to be worked on a small scale, a simpler form will suffice. A rectangular box the base of which is several inches larger each way than the largest plate to be used, and twice the height of its longest side, is fitted with a narrow hinged door extending along the bottom of the front side. A couple of trunnions are fitted one to each end of the box a little above the centre. These trunnions are supported upon a framework consisting of a bottom and two sides, but open back and front to permit of the box being partially revolved. A pound or two of powdered bitumen or resin is placed in the box, which after the door is closed is turned upside down and back again upon its trunnions with a jerky motion some ten or twenty times, till it is filled with a cloud of the bitumen dust. It is then brought to rest and the top and sides smartly beaten to dislodge any of the dust which may have adhered.

If the plate is at once placed in the box it will be covered with mingled coarse and fine particles; when a fine grain is required the box must be allowed to rest for some seconds to permit the coarser particles to settle, and in such cases it may be necessary to repeat the operations several times to obtain a sufficiency of grain.

The nature of the grain is determined by the subject to be etched, and for average work the dust may be allowed to settle for half-a-minute or so before the plate is inserted. In five or ten minutes the plate may be removed, and if on examination through a glass the surface is found to be thickly covered with dust, it is ready to be fired. For this purpose a copper-plate heater is convenient; this is a sheet of iron about a quarter of an inch in thickness, heated evenly by a Bunsen burner. The grained copper plate is laid upon a sheet of stout paper, the ends of which project far enough to permit of the plate being lifted by them without disturbing the grain, and is placed upon the heating plate and moved gently over the surface to equalise the heat.

Small plates may be heated directly over the Bunsen burner by gripping one corner in a hand-vice, the jaws being separated from the plate by a folded piece of paper.

As the heating proceeds the grain must be closely watched by bringing the eyes almost to the level of the plate, and looking across the fore-shortened surface. As the bitumen or dust begins to melt, a peculiar change in the appearance of the grain takes place; for a second or two it appears to be transparent, and then changes to a bloom as seen upon fruit; at this stage the plate is removed from the heater and is allowed to cool. If over-heated the grain will have run together, in which case it must be removed with benzole and the plate cleaned for a second attempt; if under-heated the grain will not adhere to the plate. This may be tested by brushing a corner of the plate, when if the dust is removed it must be again heated till the proper temperature is reached.

When the plate is cool it is ready to receive the "resist."

This is a negative image printed in carbon tissue from a reversed positive.

The positive from which it is made may be made from the original negative, either by contact upon transparency carbon tissue or in the camera upon a dry plate. The latter method will be preferable when the original negative embraces a considerable range of gradation, as the resist should be of such a character as if developed upon glass it would yield a rather flat print on P.O.P. The carbon tissue used for the resist may be sepia or standard brown, but the Autotype Company supply an orange tissue made specially for the purpose, and it is recommended that this should be used, as, being transparent, the action of the etching fluid can be more easily seen.

The piece of tissue selected should be carefully examined against a strong light, and if there are pinholes or other irregularities in the coating it should be rejected.

The operations are the same as when making a print by the single transfer process, but development must be carried on till all the soluble gelatine has been thoroughly removed. Some operators dry the resist by flooding it with spirits of wine; if this plan is adopted pure spirits should be used, as the mineral oil contained in methylated spirits may cause irregular markings. On the whole, better results may be ensured by giving the plate a final wash in clean hot water and by assisting the drying by gentle fanning.

As soon as the resist is dry, the edges and back of the plate should be protected with acid proof varnish. Bates's black may be used, or bitumen dissolved in benzole. A little of the varnish is taken in a draughtsman's pen and lines ruled round the image, a camel-hair brush charged with the varnish can then be used to coat the edges without encroaching beyond the boundary lines, and when these are dry the back may also be varnished.

The etching may take place in an ordinary developing dish, but a more convenient plan is to make a border round the plate with etcher's wax; this is a mixture of beeswax and Burgundy pitch, and may be obtained from the engraver's sundries-man. It is broken into pieces and thrown into a bowl of warm water; when soft it is rolled in the hands into cylinders, and these are first pressed between the folds of a cloth to remove any moisture, and then moulded along the edges of the plate to form a border about three-quarters of an inch high, and a spout is moulded at one corner. By this plan the solutions may be speedily changed and lesser quantities of the solutions are required than when the plate is etched in a dish.

The etching fluid is, as in Talbot's original process, a solution of ferric chloride, but it is now found convenient to have this in varying strengths. A quantity of the ferric chloride is dissolved in as little water as possible, and this should be boiled in an enamelled saucepan for an hour or two with a little oxide of iron added to satisfy any free acid which may be present. The solution should be allowed to stand for a day or so in a stoppered jar to allow all solid matter to settle, when the clear liquid may be decanted.

A fifth part of the solution should then be tested with a Beaumé hydrometer for heavy liquids, and water should be carefully added to it till it registers 45°. Five other solutions should be made registering say 41°, 37°, 33°, 29° and 25°.

Etching is commenced with the strongest solution. To ensure regularity of action the solutions should all be kept at the same temperature, 65° to 70° Fah.

In a well-developed resist, the deepest shadows should be almost bare copper, and it is in these parts only that the 45° solution will act. As etching takes place the copper acted upon becomes black, and so the progress of the work may be followed. As soon as the strong solution ceases to spread from the deepest shadows to those a little lighter it must be poured off, and the 41° solution quickly poured on, each solution in turn being discarded as soon as its action ceases to spread. It will generally be found that the 29° solution will etch through the highest lights, though occasionally it may be necessary to use the 25° solution when the resist is a little dense.

The time of etching will vary from five minutes to a quarter of an hour, and in making the resist it is desirable to aim at such a gradation, that this latter time may be occupied in the etching, as a quickly etched plate has but a short life in the printer's hands.

The gradation of the resist determines the time of etching. Attempts to prolong the etching by using the denser solutions after their action has ceased to spread will result in clogged shadows and foul biting.

As soon as all but the highest points of light have blackened under the mordant, the solution should be thrown off and replaced with a 5% solution of sulphite of soda, which will at once check the action, the resist should be rubbed off with the tips of the fingers, the wax border removed, and the varnish cleaned off with benzole and methylated spirit.

If the minute cavities in the plate are filled, as sometimes happens, with impurities, the plate must be boiled in a dilute solution of American potash, and resulting tarnish cleared by a brief immersion in dilute nitric acid.

Faults in the plate can be corrected with roulettes, burnishers, etc., but the use of these tools is best acquired by practical lessons from a copper-plate engraver.

As the plate rapidly deteriorates in the process of printing, only one proof should be pulled before the plate is steel-faced.

This is an operation which is best entrusted to a trade firm.

CHAPTER LI

HALF-TONE BLOCKS

HALF-TONE blocks are so much employed at the present day that some description of the method most generally used in their production must be given. Any one studying with a magnifying-glass pictures taken from photographs which are daily found in different publications will see that the effect is given by equally spaced dots, but the dots themselves are of different size. The white and the black which are in juxtaposition are mixed together by the eye as they are in line engravings, and give various shades of grey, from nearly white to nearly black, the tone varying according to the proportions of black to white. These dots are produced by placing a little in front of the sensitive plate, equally spaced crossed ruled black lines, through which the rays of light pass before forming an image on the plate. If such ruled lines were in contact with the plate, the only effect would be to give a sharp image of them, the focussed image appearing through the interstices. When, however, the lines are a little removed from the sensitive surface there will be no longer a plain network of regular lines impressed, but the interstices will appear on the photographic plate made up of dots of different sizes and of slightly different densities, the sizes of the dots depending largely on the size, and, secondarily, on the shape of the diaphragm employed in the lens.

Within limits, the larger the stop employed the more diffused will be the dots in the high-lights, and with proper exposure they should blend one into the other, and leave but small transparent dots through the filling up of the opaque surrounding, whilst in the deep shadows the dots will be opaque, but remain small.

The question may be asked why this is so. There have been many explanations advanced regarding the action of this network of lines, but the main one seems to be of exceptional simplicity. In Chapter IX. it has been shown what is the action of a pin-hole. If we isolate one of the interstices of the ruled screen we shall find that when viewing a point of light it will do exactly as a pin-hole does, and if we photograph a point of light with a lens in which the diaphragm is a pin-hole and which falls on this isolated interstice, we shall see that the image is also of a pin-hole nature. If the interstice be circular and the image be formed of monochromatic light (that coming through red glass or ammonio-sulphate of copper is sufficiently monochromatic), we shall find that when the screen is moved from contact with the plate to a small distance away, the image as developed will be composed first of a white dot surrounded by a black ring, and then a black dot surrounded by a white ring, and these alternations take place at different distances. Where the central dot is dark the image will appear smaller than the interstice itself if the exposure be not too prolonged.

If now we use two pin-holes close to the lens, and which occupy, say, extreme corners of where the aperture of the diaphragm to be used would come, two such pin-hole images will be formed side by side and overlap. If we make pin-holes at the other corners, we shall have two more images overlapping each other, and also the first two. As the number of pin-holes close to the lens is increased, we have other images formed which fill up a space on the sensitive plate larger than the interstice. If the diaphragm has an aperture of the shape of a small circle, the central part of the image will be intense, and of smaller dimensions than the interstice. The larger the stop within limits, the more the image on the sensitive plate will spread. Mr. W. Gamble gives a rule for the size of the aperture of the diaphragm, which is as follows :—Let a be width of the mesh, x of the stop, and b the distance of the plate from the stop, and c the distance of the plate from the screen.

$$\text{Then } x = \frac{a\,b}{c}$$

Thus if the mesh of the screen has an opening of $\frac{1}{200}$ inch, and its distance from the plate be $\frac{1}{10}$ inch ; then if the distance of the diaphragm from the plate be 20 inches, $x = \frac{\frac{1}{200} \times 20}{\frac{1}{10}} = 1$ in. diameter.

From what has been said, it will be evident that the shape of the aperture in the diaphragm has something to say as to the character of the dot. A square one with its side placed at an angle of 45° with that of the line of the screen is said to be the best foundation for an aperture, and this might be a squarish dot with rounded corners. What we wish to get is the square without the rounding off, and it is found in practice that by piercing small holes, say, $\frac{1}{8}$ inch diameter, at the corners of the aperture, the shape of the dot becomes a square without the rounding off, and that the neighbouring dots will join one another when the intensity of the light is moderately good, which is a consideration. In the shadows the light is so spread out that the dots are almost absent, and to break up the shadows better it is customary to expose part with the square stop for the high-light, and then to give a subsidiary exposure with a small round dot, so that the shadows may contain very small dots which only affect the parts of the dots already formed in the high-lights by the previous exposure, for, as before said, the small circular aperture of a diaphragm will give small dots in the centre of the interstices. There are certain "regulation" sizes of ruled screens found by practice as working well, which are as follows :—85, 100, 120, 133, 150, and 175 lines to the inch ; and the rule laid down in Penrose's *Pocket-book* is that the 85 lines to the inch is for coarse-grain blocks for rapid printing ; for moderately coarse blocks, 100 to the inch ; for common book and periodical work, 120 to the inch ; for average work to be well printed, 133 to the inch ; and for magazine work 150 to 175 to the inch. The width of the line compared with the transparent part has an important bearing on the success of the photograph.

It is laid down that the lines in thickness may be equal to the width of the space they enclose, and should not be less than 4 : 5. The reason of this rule is apparent, for, if less, the overlapping of the different dots would be too marked.

The distance of the screen from the plate is evidently important. Penrose gives the method employed by Count Turati of finding the distance and size of the stop by focussing. A small piece of thin microscopic glass is cemented on to the inside of the focussing-screen, and after the image has been properly focussed the screen is examined by means of a magnifier. If the stop that it is proposed to use is inserted in the lens, and the plate moved to and from the screen, and the image at the aperture of the screen examined, dark dots will appear, and as the screen is moved will appear more or less sharply defined, and will join in the high-lights corner to corner. When the definition is the best obtainable, the screen is kept in the position so formed. If the dots under all conditions are very blurred a special stop must be used, till the definition of the dots is fairly good. The distance of the screen from the plate will vary considerably—it may be $\frac{1}{32}$ of an inch, or may be half-an-inch, depending on the screen employed, and on the fineness of the line, and on the size of the stop employed.

Making the Negative.—As in the line process, described in the last chapter, a reversing mirror or prism must be used, and the wash-drawing, photograph, or other original subject to be produced in half-tone, should be illuminated by as intense a light as can be commanded.

The exposure having been made through a suitable screen correctly distanced from the plate (which should for best results be the wet-plate process), it should be developed and intensified in precisely the same manner as for line work, for it must be borne in mind that the half-tone effect is obtained by a multitude of minute dots of clear glass in the high-lights, surrounded by an opaque deposit of silver, the dots becoming larger as the lights merge into the half-tone, until in the deepest shadows they join each other at the corners with minute specks of clear glass between. To secure the clear glass and opaque dots cleanly separated from each other, the clearing effects of potassium cyanide may be relied upon, care being taken that the action is stopped as soon as the correct result has been obtained, otherwise the smallest dots will be dissolved away. Full density in the parts which should be opaque may afterwards be obtained by the use of the cupric bromide intensifier, formula No. 8, or Eder and Toth's intensifier, formula No. 9, Chapter XVIII.

Preparation of the metal plate.—The zinc or other metallic plate having been cleaned with whiting and methylated spirit, may be coated with the bichromated albumen solution given in the last chapter for line work. Several other formulæ have come into vogue, among them the enamel process, for which a formula by Mr. W. Gamble is given :—

Dried albumen	120 grains
Water	2 ounces
Mix thoroughly, and with it add ammonium bichromate ...	60 grains
dissolved in water	2 ounces
and add ammonia 880°	1 dram
Add clarified Le Page's fish-glue, and mix thoroughly with the albumen solution.	4 ounces

This formula is suitable for use with bright sparkling collodion negatives; for thin negatives and dry-plate negatives the quantity of fish-glue may be reduced. After mixing, the froth should be allowed to subside and the solution then filtered. Preferably the solution should stand in a jar covered with muslin to exclude dust for a day before use. The plate is coated with the solution on a whirler. After printing, development is begun by soaking for a minute or two in cold water; the film is then tinted with a solution of methyl violet, 1 ounce, in water 20 ounces (filtered), and development is finished by a rinse in warm water (about 100° Fah.). When quite dry the plate is heated over a gas-stove till the film is burnt to a deep brown, almost to a black.

To secure this colour the heat must be very intense—almost sufficient to melt the zinc plate.

Etching the Plate.—Etching is most safely conducted in a one per cent. solution of nitric acid, and may occupy from half to three-quarters of an hour. A stronger etching bath may be employed, but there is then a tendency for the film to lift. Success in etching depends to a great extent upon the quality of the negative. When copper or brass plates are used, the etching fluid is a solution of ferric chloride registering 35° to 45° with the Baumé hydrometer.

The operations of mounting, etc., are as described in the last chapter.

Students who wish to acquire the working details as practised in commercial houses, are referred to *Half-Tone on the American*

Basis, by Wilhelm Cronenberg, translated by William Gamble; and *The Half-Tone Process*, by Julius Verfasser, both published by Percy Lund and Co., Limited, and are recommended to obtain lessons at one of the trade houses, or at one of the institutions where the process is taught. Trade workers may obtain instruction at the Technical School, Bolt Court, Fleet Street.

APPENDIX

Easy Tests for the Amount of Silver Nitrate in the Solution.—Take half-an-ounce of the solution to be tested, and precipitate the silver as chloride by adding a slight excess of hydrochloric acid or common salt. Filter the solution off, and dry the filter-paper and the chloride over a water bath. The chloride can then be easily removed from the filter-paper, and should be weighed. The weight multiplied by 1·18 will give the amount of silver nitrate.

Another very pretty method is as follows:—Measure with a pipette (or dropping bottle) one hundred drops of the solution to be tested; rinse the pipette, and drop from it, into the silver solution, a solution of dried salt and water (thirty-five grains to the ounce), till no more precipitate of silver chloride is seen to form. The number of drops added to the silver solution will be the number of grains of silver nitrate in the ounce of bath.

There are two methods of ascertaining when no further precipitate is formed: first, by adding a drop of potassium chromate (*not bichromate*) to the salt solution, and noting when the precipitate finally has a permanent red tinge after stirring; or the solution of salt may be placed in a stoppered bottle, and be shaken between each addition of the silver. The silver chloride agglutinates by shaking, and a fresh precipitate is seen to form at once on adding another drop of silver. When all the sodium chloride is precipitated, the solution remains milky.

Utilisation of Silver Residues.—All paper or solutions in which there is silver should be saved, as it has been proved by experience that from fifty to seventy-five per cent. of the whole silver used can be recovered by rigid adherence to the careful storing of "wastes."

1. All prints should be trimmed, if practicable, before toning and fixing; in all cases these clippings should be collected. When a good basketful of them is collected, these, together with the bits of blotting-paper attached to the bottom end of sensitised paper during drying, and that used for the draining of plates, should be burnt in a stove, and the ashes collected. The ashes will naturally occupy but a small space in comparison with the paper itself. Care should be taken that the draught from the fire is not strong enough to carry up the ashes.

2. All washings from prints, water used in the preparation of dry plates, all baths, developing solutions (after use), and old toning baths, should be placed in a tub, and common salt added. This will form silver chloride.

3. The old hyposulphite* baths used in printing, and the solutions of cyanide of potassium, or sodium hyposulphite, used for fixing the negatives, should be placed in another tub. To this the potassium sulphite of commerce may be added, or else a stream of sulphuretted hydrogen passed through it till no more precipitation takes place. Silver sulphite is thus formed.

4. To No. 1 nitric acid may be added, and the ashes boiled in it till no more silver is extracted by it. The solution of silver nitrate thus produced is filtered off through white muslin, and put aside for further treatment.

5. The ashes may still contain silver chloride. This may be dissolved out by adding a solution of sodium hyposulphite, and adding the filtrate to No. 3.

6. The solution from No. 4 may next be evaporated to dryness, and crystals of silver nitrate be produced; or else common salt may be added, and the precipitate added to No. 2.

7. No. 2, after thoroughly drying, may be reduced to metallic silver in a reducing crucible † by addition of two parts of sodium carbonate and a little borax to one of the silver chloride. These should be well mixed together, and placed in the covered crucible in a coke fire, and gradually heated. (If the operator be in possession of one of Fletcher's gas furnaces,

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* If sulphite of soda be used for fixing, all that is necessary is to add to it commercial hydrochloric acid, when silver will be precipitated as chloride.

† The crucible should be of Stourbridge clay.

he can employ it economically, and with far less trouble than using the fire. It is supplied with an arrangement for holding crucibles, which is useful for the purpose.) After a time, on lifting off the cover, it will be found that the silver is reduced to a metallic state. After all conflagration has finished, the crucible should be heated to a white heat for a quarter of an hour. The molten silver should be turned out into an iron pan (previously rubbed over with plumbago to prevent the molten metal spirting), and immersed in a pail of water. The washing should be repeated till nothing but the pure silver remains.

8. The chloride may also be dissolved in sodium hyposulphite, and added to 3.

The silver hyposulphite, having been reduced to the sulphide by the addition of the potassium sulphide, is placed on a crucible and subjected to a white heat; the sulphur is driven off, and the silver remains behind.

9. A last method is that of treating the whole of the residues as hyposulphite. A sheet of zinc is placed in the tub, and the silver is precipitated in a metallic state. The supernatant liquid is syphoned off, and replenished from the other waste solutions. When the amount of silver deposited is sufficient, it is filtered out through fine calico and collected. After thorough washing it should be heated, to drive off the large amount of sulphur which is collected, and may be treated with nitric acid to form silver nitrate, or else be melted in a crucible with borax to form an ingot. If the plan be adopted of forming silver nitrate, the small amount of gold present will be left behind as a grey powder. This, after being well washed, may be treated with nitro-muriatic acid, as given below, and reconverted into tri-chloride. There will always be a certain amount of silver sulphate formed from the action of the nitric acid on the sulphur deposited with the silver.

Another method of reducing silver salts to the metallic state is by placing them in water slightly acidulated with sulphuric acid together with granulated zinc. The zinc is attacked, evolving hydrogen, which in its turn reduces the silver salt to the metallic state, and forming hydrochloric acid. After well washing, the silver may be dissolved up in nitric acid.

Yet another method is to take sugar of milk and a solution of crude potash, when the silver is rapidly reduced. This requires careful washing, and it is well to heat the metal to a dull red heat to get rid of any adherent and insoluble organic matter which may have been formed, before dissolving it in nitric acid.

To Procure the Silver Bromide from Waste Gelatine Emulsions, we recommend that the emulsion be boiled with one-sixth part of hydrochloric or sulphuric acid, which will destroy the gelatine and cause the bromide to precipitate. Another plan is to boil it with caustic potash and sugar of milk, when the silver will be procured in the metallic state.

Silvering Mirrors.—The formula used by Mr. Common is as follows:—

No. 1.—	Silver nitrate	480 grains
	Water	10 ounces
No. 2.—	Caustic potash (pure)	410 grains
	Water	10 ounces
No. 3.—	Glucose	240 grains
	Water	10 ounces

The silver nitrate solution is precipitated with ammonia, and the precipitated oxide just re-dissolved by an excess of ammonia. The caustic potash solution is then added, which re-precipitates the silver oxide. The new precipitate is again just re-dissolved by ammonia. A weak solution of water (five grains to the ounce of water) is then dropped in till there is a very faint opalescence. The solution should be allowed to settle to get clear. No. 3 is added just before the silvering is to take place.

The plate is prepared as above, and the silvering solution poured on. The mirror should be finished in about twelve to fifteen minutes if the temperature be about 60°.

To Make Gold Tri-Chloride [AuC$_3$].—Place a half-sovereign (which may contain silver as well as copper) in a convenient vessel; pour on it half a drachm of nitric acid, and mix with it two and a half drachms of hydrochloric acid; digest at a gentle heat, but do not boil, or probably the chlorine will be driven off. At the expiration of a few hours add a similar quantity of the acids. Probably this will be sufficient to dissolve all the gold. If not, add acid the third time; all will have been dissolved by this addition, excepting, perhaps, a trace of silver which will have been dissolved by the excess of hydrochloric acid as silver chloride. If a precipitate should have been formed, filter it out, and wash the filter-paper well with distilled water. Take a filtered solution of ferrous sulphate (eight parts water to one of iron) acidulated with a few drops of hydrochloric acid, and add the gold solution to it; the iron will cause the gold alone to deposit as metallic gold, leaving the copper in solution. By adding the gold solution to the iron the precipitate is not so fine as if added *vice versâ*. Let the gold settle, and pour off the liquid; add water, and drain again, and so on till no acid is left, testing the washings by litmus-paper. Take the metallic gold which has been precipitated, re-dissolve in the acids as before, evaporate to dryness on a water bath that is at a heat not exceeding 212° F. The resulting substance is the gold tri-chloride. To be kept in crystals, this should be placed in glass tubes hermetically sealed. For non-commercial purposes it is convenient to dissolve it in water (one drachm to a grain of gold). Ten grains of gold dissolved yield 1·54 grains of salt. Hence, if ten grains have been dissolved, 15·4 drachms of water must be added to give the above strength.

To Remove the Varnish from a Negative.—Varnish may be removed from a negative by warming it gently, and applying spirits of wine to its surface. The spirit must be poured off, the plate re-heated, and a fresh quantity applied as before. This operation must be continued till the varnish appears to be totally dissolved from the surface of the negative. Alcohol vapour made by heating spirits of wine over a spirit-lamp in a test-tube is very rapid in its solvent action. A final rinse of spirits should, however, always be given. A moderately strong solution of caustic potash will also remove most varnishes, and is recommended as simpler than the first method when collodion films are in question.

WEIGHTS AND MEASURES.

1 Sovereign weighs	123·274 grains
1 Shilling „	87·273 „
48 Pence weigh	1 lb. avoirdupois
Half-penny and three-penny piece weigh	¼ ounce
Florin and Sixpence	½ „
Three Pennies	1 „
4 Half-crowns and 1 Shilling	2 ounces
4 Florins, 4 Half-crowns, 2 Pennies	4 „

1 Half-penny = 1 inch in diameter

Avoirdupois Weight.

$27\frac{1}{32}$ Grains	1 drachm	(= $27\frac{11}{32}$ grs.)
16 Drachms	1 ounce	(= 437½ „)
16 Ounces	1 pound	(= 7000 „)

Troy Weight.

24 Grains	1 pennyweight	(= 24 grains)
20 Pennyweights	1 ounce	(= 480 „)
12 Ounces	1 pound	(= 5760 „)

Old Apothecaries' Weight (superseded in 1864).

20 Grains	1 scruple	(= 20 grains)
3 Scruples	1 drachm	(= 60 „)
8 Drachms	1 ounce	(= 480 „)
12 Ounces	1 pound	(= 5760 „)

The New Apothecaries' Weight is the same as Avoirdupois.

Liquid Measure.

60 Minims	1 drachm	
8 Drachms	1 ounce	= 1·73 cub. ins. nearly
20 Ounces	1 pint	= 34·66 „ „
8 Pints	1 gallon	= 277·25 „ „

The Imp. Gallon is exactly 10 lbs. Avoir. of pure water; the pint, 1¼ lbs.

FLUID MEASURE.

1 Minim =	1 drop	2 Drs. =	1 dessert-spoonful
1 Drachm =	1 teaspoonful	4 „ =	1 table „

FRENCH MEASURES.

1 Gramme ... ... 15·432 grains
Kilogramme .. ... 1000 grammes (= 2·2 lbs. avoir. nearly)
1 Litre ... ... 35·216 ounces (fluid)
1 Ounce ... ... 28·4 c.c.
1 Cubic Centimetre (c.c.) 17 minims nearly
50 Cubic Centimetres 1 ounce 6 drachms 5 minims
1 Metre ... ... 39·37 inches

TABLE OF THE SYMBOLS AND COMBINING WEIGHTS OF THE MOST COMMON ELEMENTS.

Name.	Symbol.	Comb. Weight.	Name.	Symbol.	Comb. Weight
Aluminium	Al	... 27·4	Lead	Pb	... 207
Antimony	Sb	... 122·0	Lithium	Li	... 7
Arsenic	As	... 75	Magnesium	Mg	... 24
Barium	Ba	... 137	Manganese	Mn	... 55
Bismuth	Bi	... 210	Mercury	Hg	... 200
Boron	B	... 11	Nickel	Ni	... 58·7
Bromine	Br	... 80	Nitrogen	N	... 14
Cadmium	Cd	... 112	Oxygen	O	... 16
Calcium	Ca	... 40	Palladium	Pa	... 106·6
Carbon	C	... 12	Phosphorus	P	... 31
Chlorine	Cl	... 35·5	Platinum	Pt	... 98·7
Chromium	Cr	... 52·2	Potassium	K	... 39·1
Cobalt	Co	... 59	Silicon	Si	... 28
Copper	Cu	... 63·5	Silver	Ag	... 108
Fluorine	F	... 19	Sodium	Na	... 23
Gold	Au	... 197	Strontium	Sr	... 87·5
Hydrogen	H	... 1	Sulphur	S	... 32
Iodine	I	... 127	Tin	Sn	... 118
Iridium	Ir	... 198	Uranium	U	... 120
Iron	Fe	... 56	Zinc	Zn	... 65·2

CHEMICAL COMPOUNDS TO WHICH REFERENCE IS MADE IN THE BOOK.

New Nomenclature.	Symbols.	Common Names.
Ammonium bromide	$NH_4 Br$	Bromide of ammonium
„ chloride	$NH_4 Cl$	Chloride of ammonium
„ iodide	$NH_4 I$	Iodide of ammonium
Barium nitrate	$Ba (NO_3)_2$	Nitrate of baryta
„ sulphate	$Ba SO_4$	Sulphate of baryta
Cadmium bromide	$Cd Br_2$	Bromide of cadmium
„ chloride	$Cd Cl_2$	Chloride of cadmium
„ iodide	$Cd I_2$	Iodide of cadmium
Calcium chloride	$Ca Cl_2$	Chloride of calcium
Cupric chloride	$Cu Cl_2$	Chloride of copper
Ferric nitrate	$Fe (NO_3)_3$	Pernitrate of iron
„ sulphate	$Fe_2 (SO_4)_3$	Persulphate of iron
Ferrous nitrate	$Fe (NO_3)_2$	Proto-nitrate of iron
„ sulphate	$Fe SO_4$	Proto-sulphate of iron
Gold tri-chloride	$Au Cl_3$	Terchloride of gold
Hydrogen sulphide	$H_2 S$	Sulphuretted hydrogen
Iridium chloride	$Ir Cl_3$	Chloride of iridium
Mercuric chloride	$Hg Cl_2$	Bichloride of mercury (corrosive sublimate)
Mercurous chloride	$Hg Cl$	Calomel
Platinum tetrachloride	$Pt Cl_4$	Bichloride of platinum
Potassium bromide	$K Br$	Bromide of potassium
„ chloride	$K Cl$	Chloride of potassium
„ iodide	$K I$	Iodide of potassium
„ dichromate	$K_2 Cr_2 O_7$	Bichromate of potash
„ permanganate	$KMnO_4$	Permanganate of potash
Silver bromide	$Ag Br$	Bromide of silver
„ chloride	$Ag Cl$	Chloride of silver
„ iodide	$Ag I$	Iodide of silver
„ oxide	$Ag_2 O$	Oxide of silver
„ nitrate	$Ag NO_3$	Nitrate of silver
„ sulphate	$Ag_2 SO_4$	Sulphate of silver
Sodium chloride	$Na Cl$	Common salt
Sulphuric acid	$H_2 SO_4$	Sulphuric acid
Zinc iodide	$Zn I_2$	Iodide of zinc
„ bromide	$Zn Br_2$	Bromide of zinc
„ chloride	$Zn Cl_2$	Chloride of zinc

INDEX

THE END

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